ENGLAND'S WORKSHOPS.

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PREFACE.

WHILE there are few persons who can give a very clear account of the processes by which several of our commonest articles of utility are manufactured, there are a great number who desire to know something more about them.

It is only necessary to listen to the remarks of the visitors at any Industrial Exhibition, to discover that there are a hundred scientific and mechanical problems which remain unsolved by several inquirers, who scarcely know where to look for information.

This is so obviously the condition of the younger portion of such an assembly, that surely nothing but that fear of innovation which exercises so depressing an influence in many of our schools, would have prevented the use of some recognised work on this subject, as one of the ordinary reading books.

The present volume is a faithful record of a series of visits to some of the great workshops in various parts of the country.

It would be impossible, within the compass of a single volume, to include a reliable account of one of each variety amongst the multitude of England's workshops,—but it is believed that the manufactures here described are sufficiently various to be generally interesting, and the writers have endeavoured to present them in as popular a form as the nature of the subject would admit.

It is of course not to be understood that all the manufactories mentioned here are represented as having a superior claim to others engaged in the same branches of industry, either as regards the extent of their operations, or the quality of the articles which they produce. To this there are a few well-known and important exceptions; but in the majority of instances the places were selected either because they were more accessible, or from other circumstances, which, at the time, made this selection desirable.

Several of these descriptions have already appeared in the columns of the 'Illustrated Times,' and some others in the special scientific and trade journals (such as the 'Chemist and Druggist,' &c.), of Messrs. Morgan Brothers; but in all these cases the articles have been subject to careful revision, and have received many important additions.

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METAL WORKSHOPS.

The industry of man is exerted principally in three directions, and may accordingly be divided into three principal branches, viz., the *producing*, the *manufacturing*, and the *commercial*.

The first draws from the inexhaustible stores of all-bounteous nature the raw materials—the rich mineral ores, the produce of the field, the pastures, the garden, the orchard, the forest. It embraces all the operations of mining and agriculture, and general husbandry; the breeding and tending of cattle, the planting and rearing of trees, &c. &c.

The second adapts the raw materials supplied by the first, for the purposes for which they are required. The third has for its object the proper distribution of both the raw material and the manufactured article; it conveys them from places where they are found in abundance to others where they are needed.

Each of these three branches of human industry may fairly claim the attention of an inquiring mind; yet, to our thinking, none more so than the second. There can hardly be a more interesting subject for contemplation than the processes and operations by which man converts, moulds, and fashions the raw materials supplied by nature into forms, fitting them for his use or enjoyment. Yon confused heap of dirty, tangled, and clotted wool, emitting unsavoury smells, and that comfortable garment in which Paterfamilias bids defiance to the inclemency of the season, and which, maybe, is not altogether foreign to the impulse that urges him to bestow consolation and relief upon his less fortunate brethren; or, yonder lumps of crude ore, and that marvellous collection of multifarious and multiform articles, for use or ornament, which bewilders the gaze of the visitor

to an ironmongery warehouse; what are they but the beginning and the end, as it were, of the same chain? It will be interesting and instructive to trace some of the intermediate links of that chain, and to watch the operations that have wrought such surprising transformations!

GILLOTT'S STEEL PEN MANUFACTORY, AT BIRMINGHAM.

"EVERY man to his trade" having been for ages accepted as one of those imperative maxims the wisdom and authority of which are alike indisputable, we find ourselves in an express-train of the Great Western rattling on towards Birmingham at a speed with which even imagination (always less difficult than description) could scarcely keep pace. Of course, in quoting the popular proverb, we at once indicate that our own trade is writing, and, having stated that much, it is almost unnecessary to mention that we are bound on an excursion to inquire into the natural history of steel pens.

If anybody wishes to raise an objection to the expression "natural history" on the plea that it is more applicable to "quills," we beg leave at once to differ, and boldly avow that we can see nothing natural whatever in plucking the feathers from a harmless, not to say silly, bird, for the purpose of inscribing for the benefit of mankind "thoughts that breathe and words that burn" in imperishable characters. "*Vive la plume!*" by all means, but let it be on its native wing; while the "nib," too flexible to splutter and yet too firm to blot, characterises the literature of a greater age.

We are perfectly acquainted with the doggerel assertion of the celebrated bishop who, after labouring to the completion of an enormous volume, wrote, with a triumphant flourish,

> With one whole pen I wrote this book,
> Made of a grey goose quill;
> A pen it was when I it took,
> A pen I leave it still.

To what a desperate state of mind must that man have

been driven before he could write in this way of even the worst pen! To what verges of insanity must the readers of his manuscript have gone before they could decipher the blurred and uncertain characters! We are looking out of window towards Stratford-upon-Avon and the house of Shakspeare. Where, let us ask, would have been the occupations of commentators vainly disputing over various readings if the steel pen of modern science could have been substituted for the quill of the immortal "Swan?"

Even after considerable research it is difficult to discover who was the first actual inventor of steel pens; but it would appear that the earliest attempt to manufacture them was that of a Mr. William Gadbury, a mathematical instrument maker, who, for his own use and that of his friends, constructed a somewhat clumsy article out of steel watchspring, from which were formed the two separate halves or "nibs," which were then brought together and secured by a metal band. His was only an amateur performance, however, and we believe it is principally to Mr. Joseph Gillott, of Birmingham, that we owe the perfection to which steel pens have been brought, since at the time when he commenced business, some forty years ago, much of the beautiful machinery now used in his manufactory had yet to be invented, and *was* afterwards invented by himself.

Being expected at the factory, we have little leisure to bestow upon the Hen and Chickens, where the five commercial gentlemen are sitting down to breakfast and speaking together in the low and solemn tones generally adopted in the room set apart for their accommodation; so turning down towards the vast and imposing Townhall, the windows of which we notice have not been cleaned lately, we branch off in the direction of the New Turkish Baths (a very handsome structure, by-the-way), and find ourselves opposite the place of which we are in search.

It is an immense brick building, which looks something like a large asylum, a little like a manufactory, and more like an hospital than either, except that it stands unenclosed at the corner of a street, and two or three chimneys appear above it indicating that its inner quadrangle is devoted to machinery. There is no doubt of its being the right place, however, for there is the gate surmounted by the Royal arms,

and here in the office up the stairs, as we enter the door at the side, we are met by one of the sons of Mr. Gillott himself, who confides us to the guidance of a superintendent. To him we make known our anxiety to see the various processes by which the raw material is converted into the beautiful "extra superfine," the gigantic "swan quill" magnum bonum, or the "school pen" with which our earliest experiences in caligraphy are associated.

The steel itself, which is manufactured of Swedish iron, is supplied in large thin plates by Messrs. Jessop and Son, of Sheffield, and the first of the series of operations towards converting it into pens commences in a room where a man is at work with a large lever-knife, like the blade of a hay-chopping machine, cutting the metal into long strips of the width required for the lengths of the different sorts of pens. Not having been hardened, these slips are carried into the rolling-room, where they are placed between steel rollers which revolve by means of steam machinery, and are only a sufficient distance apart to admit each strip, and press it as it passes between them to the proper and uniform thinness. The even bands of white glittering steel are then removed to the upper part of the factory, a range of light, clean, workshops, well warmed and well ventilated. In these large rooms, which lead one into another, there are employed some five hundred girls and women—in busy times as many as six hundred—of whom a large majority appear healthy, and, if the nature of their work is considered, they must be tolerably strong. Indeed, there would seem to be nothing in any of the processes of pen-making which is essentially injurious to those engaged in it; and, as the wages average from four to fourteen shillings a week, this establishment exhibits, perhaps, one of our most successful experiments in the employment of women.

Those of the hands who are married generally go with their husbands to live at their former homes, in which case their children are intrusted to the care of the grandmothers; and the earnings are not seriously diminished. We learn this much as we walk with our guide through the room to inspect the next destination of the steel strips. They are lying, a certain number of them, beside each of the workwomen, as she sits at the lever by which the flat shape of the pen is punched out by a die, before it is curved into the half-cylindrical form.

These levers are all worked by hand, the strip being pushed with the left hand on to the bed of steel upon which the die descends, a stop regulating the distance, so that there is the smallest possible space between the holes left where the pen shape has been cut out; then with a quick pull at the lever handle the punch comes down, and this is repeated with such rapidity that the shapes are cut at the rate of about two hundred a minute. In a similar manner the side slits are cut, and the hole in the centre of the pen is pierced at machines which differ very slightly from those which we have just left. The stamping of the name, however, requires the workwoman to use both hands for the purpose of properly adjusting the pen and holding it in its place, and in this operation the lever is moved by a treadle and wheel. Altogether this seems rather a dangerous process, and such was the rapidity with which it was executed that we were forcibly reminded of the old school trick of moving the finger backward and forward under a regularly descending penknife. There is one machine worked by steam, and used, we believe, for the largest "magnum bonums," which performs all these operations at the same time, these pen-shapes being brought alternately to three openings in the steel slab, and the dies descending upon them as they pass. This, however, is used only for the one description of pens.

The embryo pen, having received the side slit, piercing, and stamp, has next to be moulded into the half-cylindrical form, and in the case of the magnum bonums to have the broad part, which is left for the barrel, bent completely round. This having been accomplished, still with a hand-worked lever and mould, the pen is complete as far as mere form is concerned. In the range of shops where these levers are at work, there are machinists constantly employed to sharpen the dies and regulate the machines, while each of the girls is expected to keep the machine at which she works in good order, a rule so well observed that most of them are without a stain and polished with no little care.

Still following the pens in their progress towards perfection, we descend once more to a shop in the basement, something between a bakehouse and a smithy, where the furnaces are glowing so fiercely that the sharp draught coming round the corner by the open door cuts like a knife into a mass of heat. It is here that the annealing and hardening processes are accomplished, and the fine temper secured by the

ordeal of fire. For partly effecting this process the pens are placed in iron boxes, each somewhat larger than a card-box, having a heavy lid lifting on a hinge, and at one end a small flat piece of iron, by which it is held in a pair of long tongs. These boxes are placed in the furnace, where they remain until they and their contents are at a light red heat, and look like blocks of Flanders brick, when they are withdrawn one by one by the man wielding the tongs, who holds them over a large metal tank, and, by a dexterous twist, empties them into the oil with which it is filled.

Having lain at the bottom of the tank for a short time, the pens, now sufficiently hardened, are placed in a kind of revolving sieve, and the oil which still remains after draining is expelled by centrifugal force. They are then taken into an adjoining room, where a number of iron barrels revolve on a common axis by steam power. These barrels, which are filled with sawdust, are for the purpose of cleaning the pens from the oil which still adheres to them; and a second series of barrels containing finely-broken "pot" afterwards receive them for the purpose of removing the scale left by the action of the fire. Once more they journey to the upper workshops that they may be ground longitudinally towards the points and then transversely across the nibs; this operation gives the pen the required degree of elasticity, and is technically called "glazing," from the fact of the process being performed by holding them on emery wheels turned rapidly by steam. This is a very important part of the manufacture, requiring nicety both of touch and sight to judge of the proper degree of grinding required, and it is not a little interesting to stand at the end of the workshop and watch the jets of bright steel sparks springing from the long row of wheels.

One other operation, perhaps the most important of all, and the merely useful processes are completed. This is, the making of the slit, which is effected by levers and dies still moved by the hand by means of upright handles, which give the force and weight requisite to cut cleanly through the hardened steel.

The rapid waving motion of these polished bars of metal as they are pulled and released at each stroke has a singularly pretty effect, looking like a sort of drill at which a long row of female volunteers are engaged; the only

drawback to this fancied resemblance being that they are all seated.

The vigorous cleaning and final cutting now gives place to the last two processes, which have the effect of beautifying, and the pens are carried into the shop where they are to be coloured, either blue or brown, a result effected in a few seconds by a still further application of regular heat.

The machine employed resembles an ordinary domestic coffee-roaster, being, indeed, no more than a cylindrical barrel, which a man turns by a long handle, in a raised trough containing a clear fire. At a signal from a companion, who is watching the pens through the open end of the cylinder, he lifts this off at the proper moment, when the brown or the blue tinge becomes apparent, and throws the pens upon an iron plate, where they are suffered gradually to cool before the "finishing" or "varnishing."

This finishing is achieved by placing the pens in a small metal pail with a perforated bottom, which is plunged (after the manner of an ice-making apparatus) into an outer pail or jacket containing a varnish of shellac and spirit. The contents of the inner vessel having been sufficiently saturated, it is withdrawn, and the workman swings it rapidly round and round, as though he were practising the shoulder exercise with a dumb-bell. This has the effect of dashing off the superfluous mixture adhering to the pens, which are then thrown into a sieve and shaken rapidly over a warm plate until the spirit is evaporated, and the last clear and beautiful polish announces perfection.

Then they are taken up to the warehouse, sorted, arranged, and placed in the fancy boxes which, having been made on the establishment, are waiting to receive them. Before we go, however, we must devote a few minutes to the manufacture of the "holders," or rather pensticks, which is particularly interesting, though not easily explained.

Almost all the operations connected with the pen are conducted by hand labour, since there is required in the various processes that exercise of intelligence which can never be obtained by mere machinery. Still, the uses to which steam is applied in the works require some sixty-horse power, and no inconsiderable proportion of this is devoted to the stickmaking.

The trees and logs of cedar or other wood having been

sawn into boards and again slit into thin square lengths, the rounding is managed by a machine in which a tube receives the end of each, which, as it is drawn through to the other side, is subject to the paring of a couple of revolving blades. After this it falls out at the other end perfectly cylindrical although rather rough. The roughness is obviated by another similar machine, and a bundle of the long rods is then carried to a large mahogany slab, through a slit in which is seen about a third part of the disc of a circular saw.

The rods are laid flat upon the table and brought against a gauge which regulates the length. They are then pushed towards the saw and cut into sticks, a dozen or so at a time. These plain sticks have yet to receive the spiral pattern, to have the end which receives the holder reduced in size and the other end rounded. These operations are effected not by cutting but by pressing, and one machine suffices for the purpose. They are placed, perhaps fifty at a time, in a receiver like the top of a coffee-mill, and disappear one by one into a lower chamber, where all this is done by an artful arrangement of dies, after which they make their appearance in quick succession through a tube, and fall into a box beneath.

The end of the warehouse is occupied by a number of chairs, upon which it is customary for visitors to wait until their turn comes to be shown over the works. For this manufactory is one of the sights of Birmingham, and it not unfrequently happens that so large a number of persons apply for admission that they have to be divided into parties, lest the business of the place should be disturbed. To anybody who has seen the exquisite processes which are so rapidly effected by the machinery in its wonderful adaptations this is not surprising; and there is throughout the workshops such an appearance of lightsomeness, cleanliness, health, and comfort, that it seems to wear a sort of holiday air, notwithstanding the constant labour going on there. The weekly account of "gross" boxes requires the assistance of the numeration table to write down, while the annual number of pens reaches point after point till it passes "tens of millions," and only stops at "hundreds of millions."

Of this we are heartily glad, and, though we should like to learn what becomes of them all after they are thrown aside, there is no statistical information on that part of the subject.

We are glad, also, to know that Mr. Joseph Gillott, the father of the gentlemen with whom we are sitting, has himself reaped the reward of his untiring industry and great mechanical skill, and that he has the credit (displaying that appreciation of art which is always allied to inventive genius) of having formed at his residence near Birmingham one of the finest collection of pictures in the whole of the midland counties.

THE GAS BRANCH AND CHANDELIER MANUFACTORY OF MESSRS. STROUD AND CO., AT BIRMINGHAM.

Again we find ourselves in the "hardware village" on a quest which bids fair to realise the fabled offers of the merchant mentioned in the story of Aladdin, who went through the streets crying, "New lamps for old ones!" Leaving London by that unnaturally early train to secure which it is necessary to pass the previous night in a state of spasmodic wakefulness, we reach the North-Western terminus so much too soon that the great waiting-room looks blankly reproachful, and the discharged soldier, who has evidently been "making a night of it" in another way, and wears his shell-jacket open that he may expose his throat and chest to the chill air of dawn, seems strangely sleepless amidst the profound quiet of the yawning station. Continuing our broken slumbers in a jerky series, alternating with wakeful shivers and a general sensation of numbness at the extremities, we hear the final whistle which announces our approach to the New Street station, and refreshed by a hasty breakfast, at once devote ourselves to the investigation of a subject which in its very nature requires to be luminously treated. But for unfounded objections to a discursive style, in what marvellous reminiscences might we not lose our too painful appreciation of the cobble-stone causeways of Birmingham! To say nothing of candles, a theme which would include all history and suggest lively parantheses ranging from the Jewish Tabernacle to Alfred the Great, the consideration of lamps alone would involve

retrospective sketches of eminent characters, from Gideon to Mr. Winsor and the promoters of gas. The very mention of the latter, however, is a salutary check to wandering fancies; for it is principally of "gas-chandeliers" and some other modern appurtenances of artificial light that we have to speak; and here at the establishment of Messrs. Stroud and Co. a little district of workshops is busy with the dozen processes which are necessary to satisfy an ever-increasing demand for cheap and ornamental appliances of the various descriptions of illumination.

To speak of the manufactory as a little district of workshops is not very wide of the mark, especially as part of the buildings consists of two or three streets of houses which were bought as they stood and at once converted to their present purpose, their external features but little altered, their open doors and windows revealing forge, and anvil, and workbench, their long upper casements with no idlers lounging at the sills. Having been consigned to courteous and intelligent guidance, we pass into the model-room in which various plaster-casts of designs for ornament and branch hang upon the walls. The designing and modelling, however, are principally executed by a staff of outdoor artists; and casting from the models is, in reality, the operation which may be said to have the first place in the factory itself. A complete range of shops are occupied with the casting, and in each of them forge and mould are continually at work. The mould itself is a square frame mostly of iron filled with the peculiar dark red sand of the neighbourhood, which is pressed into a firm mass, in which the patterns of the casting are imbedded and their perfect shape impressed. The casters work at a large trough filled with the sand, and the workshop, with its forge, has some resemblance to a bakehouse where black bread is being kneaded into loaves. The first mould is made for what is called "the odd side" of the pattern—that is to say (in solid castings) the lower or inferior side—and this serves as a sort of pattern to which the moulder refers. The pattern being lifted off or out as soon as the sand mould is sufficiently solid, the whole surface, in which the chasing of the pattern is clearly defined, is dusted with bean flour or pounded "pot" first, and afterwards with loam, sand, charcoal, or coaldust. This has the effect of making a smooth surface and effectually filling the interstices in the sand so

as to prevent any raggedness in the casting. Each mould, or rather the two sides of the mould, are then placed near the furnace and slightly baked, a channel having been made in the edge of each for conducting the melted metal to the pattern. The two sides are then placed together and held firmly by their pins and sockets, and the mould is ready for the casting. The "pots," or crucibles of greyish clay, which turn red by the action of the fire, are in the furnaces like so many tall flower-pots. The dirty-yellowish brass ingots, made on the premises at a large mixing-furnace, having been first placed across the tops of the pots that they may expand before being melted, are about twenty minutes afterwards reduced to a molten mass, above which hovers a light sea-green flame mingled with streaks of brilliant colour like the water from a dyehouse; meanwhile, the moulds have been placed in a slanting position, with the opening in the side upwards, against a bank of sand or brickwork, and everything is prepared for pouring. A man, who should be strong in the wrist, stands on the furnace, which has the openings at the top, like a French cooking-stove, and, taking off the brick covers from the square aperture, whence rushes out a tongue of green flame lifts out the pot with a pair of tongs and hands it to the pourer, who fills each mould in succession. The fumes which rise from the midst of the coloured fire are peculiar and penetrating, and the zinc eliminated from the molten brass falls in a metallic snowstorm, its flaky particles adhering to everything with which they come in contact, while the resistance of the sand to the metal causes a series of reports like muffled pistol-shots.

The brass cocks and plugs used in gas-fittings are all cast in one central stem, like cherries on a stick, their hollow forms being secured by means of cores, made of hardened sand, placed in the shapes impressed in the mould. These are broken off the central stem with a pair of pincers immediately after casting.

The ornamental "vases" and larger ornaments which form the body of ordinary gas chandeliers and lamps are shaped out of thin metal by a process called "stamping out," the plates of metal being placed on a hollow die, upon which a heavy hammer, or rather weight, is brought down, being released from a latch and worked by the foot. The depth of the casting would make so heavy a blow necessary that

there would be danger of splitting the metal, an accident which is prevented by the introduction of a leaden shape and a layer of clay, which is decreased after each blow of the hammer until the proper depth is gradually secured without injury.

Ascending flights of steps, and turning all sorts of strange angles, we find ourselves in one of the most interesting of the shops which looks like an engineer's workroom, hung as it is with all sorts of metal tools and shapes of cast metal. It is here they conduct the process called "reversing"—an operation which secures a hollow casting, the inner or hollow side being called the "reverse." For this purpose a mould is made from one in wax, and the impression in the mould hardened so that another model can be taken from it. This enables the moulder to secure a core which fits the impression in the mould as one cup would stand inside another; and between the mould containing the sunk pattern and that with the projecting core there are placed strips of black clay (previously rolled on a dirty pieboard), to secure sufficient thickness of metal, by not allowing the cup to be too accurately filled. The pattern when cast is "laid out" on a hollow hemisphere of iron filled with pitch, and the irregularities of the casting removed by hand tools. In the case of figures, such as Cupids, &c., forming ornaments for candelabra, the various limbs have often to be modelled in separate "cores," which are afterwards baked hard, and put together like a puzzle-map imbedded in the sand of the mould previous to casting. This requires great skill to effect successfully, and an experienced "reverser" is a man of mark in the factory.

The completed castings are now removed to the chasing-room, to which we follow them, and watch the gradual process of beautifying to which they are subjected, and the sharpening of the ornamental details by means of tool and graver, in a similar way to the first rough "laying-out" which removes the irregularities of the pattern. It is in the chasing room, too, that we see those magnificent hall-lamps—great spheres of engraved crystal, encircled with a bronze meridian at which the globe divides—for which the firm are already so celebrated. The arms and branches which form a part of the gas-chandelier work, as well as many of the scrollwork lamp ornaments, are cast in halves, which are taken to be joined in the soldering-room, where a workman

seated at a forge-like furnace heats them in the burning embers and applies to the edges the solder, with which is mingled a flux of borax and water to secure its melting. The heat is increased by a blowpipe, which is in reality a double or jacketed tube, the inner one supplying gas and the outer being connected with a large pair of bellows, and mixing atmospheric air with the lighted gas at the point of combustion.

From shops where a long series of lathes are perpetually turning for the manufacture of "threads," screws, and sockets, and the finishing of the various parts, we follow the progress of the castings through a yard where the great boiler lies like a mammoth monster asleep, pass up a flight of brick steps leading to the great chimney-stack, and find ourselves in the "pickling-room." Before this stage, however, the work is placed in a muffle or furnace-oven for the purpose of annealing, where it is also burnt with a flame which removes the particles of borax and the rougher part of the dirt.

The pickling-room is a large shed-like place filled with tubs, troughs, and earthen pans. Into one of these, containing diluted aquafortis, the metal is plunged for the purpose of removing the scale produced on the surface by the action of the fire; from this it is dipped in a stronger solution to undergo the process called "fizzing," and its final baptism in pure acid restores the beautiful primrose colour which properly belongs to it.

It is still dull, however, and goes to be "scratched;" an operation effected by means of a revolving wire-brush, turned by a wheel and treadle, and kept continually wet with water. The ornamental processes have next to be visited, and these are many. Previous to burnishing, the work is dipped in argol or tartar (the lees of wine-casks steeped in water), so that it may be subject to a strong antioxyde. The burnishing itself produces those bright veins and ornamenal surfaces so often seen in chandeliers, and is effected by fixing the work in a vice and rubbing the parts of the pattern which are to be brightened, with a steel tool having a smooth bevel edge. After being treated with ox-gall bean flour, and acid, to remove any still adhering grease, the work is dried by being first dipped in hot water and afterwards buried in a pan of warm sawdust. Then there is lacquering, both white and black, a simple process enough

since the lacquer is laid on with a brush and the work dried on a warm plate; and bronzing in various colours, of brown and green and gold.

We have already spoken of the lathes which turn the threads and screws. There are two long rooms devoted to this part of the manufacture, where all the small brass gas fittings are made and cut by machinery. Lathes, and horizontal motions, and circular cutters whirr and hum there as though the inhabitants of a hundred beehives were in full activity. To an unsophisticated mind, however, the most marvellous of all the engines is one which even while you stand watching it converts a single piece of straight wire into a complicated linked chain, or even, by a slight arrangement of its mechanism, to any one of three sorts of chains. To describe the process would be difficult. Let it suffice to say that the wire passing along a groove in the bed of the machine has a short length cut off, that by an artful contrivance of latches this length is caught, turned over, doubled, twisted, formed into a link, and that at the same moment the next section of wire has threaded it, and will in its turn, and while attached to its fellow, undergo the same process until a magical chain coils itself on the other side, and the straight line of wire reaches its last inch. These chains, which are part of the ornamentation, are used for supporting the chandelier weights. Those which are made of iron are taken to the depositing-room, there to receive a coating of copper or brass by means of electro-galvanism, and to be scoured in sand and water. The separate parts once completed, the entire chandelier is fitted together by experienced workmen and thoroughly tested as to its perfect soundness by means of a hand-pump, which forces water through every tube with sufficient stress to detect the slightest fissure. It is then measured in every part and thoroughly adjusted before being removed to the warehouse.

Although much of the machinery is admirable, and with great difficulty and expense is but just perfected, it will be seen that many of the most important operations are conducted entirely by hand labour. Perhaps one of the most interesting of these is the preparation of the glass globes, reflectors, or ornaments which accompany the now completed lamp or chandelier. Those arabesques, stars, running lines, vandykes, and often intricate traces which appear on the most costly glass fittings

of chandeliers and hall lamps are produced, without any previous drawing of the design, by grinding the glass itself on a wheel; that is to say, the workman, holding the glass in his hands, with no more indication of the pattern than two or three pencilmarks dividing the globe or plate, grinds out the pattern on a wheel of Craig Leith stone, guiding the brittle material by eye and hand with a precision and rapidity perfectly marvellous. We are very earnestly solicited to try our hands at grinding a star, but, fearful of consequence, maintain a modest discretion. For the heavier work an iron wheel is used upon which wet sand is thrown, and, the pattern once cut, the globes or plates are polished on a wheel of wood. They are, of course, ground before being cut, and for this purpose are fixed on a lathe, where while revolving they are subject to the pressure of a bunch of wire dipped in wet sand, and passed over their entire surface. The gilding and painting, which, like the grinding, are effected without a previous pattern, and by the brush alone, need little description: the gold is burnished in the same way as the branches and ornaments.

Leaving the numerous hands, or rather pairs of hands, busy with the various operations of their craft, there remains only to see the pattern-room, a long upper-story warehouse, skylighted, and its walls and supporting beams and pillars hung with a forest of brazen leaves and scrolls and devices of a thousand forms, which look like strange foliage hanging, dry and dusty under the summer sun.

This concludes our visit to the works, and we go to inspect the combined results in the multitude of cheap moderator lamps, light but elegant gas-burners, magnificent chandeliers of gold and bronze, and glass, which are waiting to be sent away. Amongst the moderators there are some of suberb and yet classical design, with an exquisite delicacy of finish and a beauty of colour which are far superior even to the gorgeous fittings of their more pretentious neighbours.

Coming away from this factory, we find ourselves wondering at the immense variety in the appliances of artificial light, no less than at the number of means for obtaining the light itself. From the plainest and cheapest French lamps—to which a room is devoted under the superintendence of a French workman—ordinary, unpretending gas-branches, lamps of curious construction for the colonies, and severely modest chandeliers, to gigantic and elaborate

structures for churches, libraries, public halls, and banqueting-rooms, all varieties have had a place in the processes which we have just witnessed, while the marvellous adaptations of machinery have effected an improvement in the production even of the cheapest amongst the ordinary gaslight fittings which should snuff out the old dip candle altogether and inaugurate a more cheerful era.

MR. CHARLES REEVES' SMALLARMS FACTORY, AT BIRMINGHAM.

THRICE is he armed who hath his quarrel just; and at least four times armed is he who, having no quarrel at all, and intending to have none, is yet prepared honestly to hold his own, keeping his dogs of war well trained and sharp of tooth, yet restrained by the leash of good-will, and amicably muzzled. This sentiment, which, but for the obvious necessity of a slight *détour* in walking through an opening paragraph, might have been expressed by the now popular proverb "Defence not Defiance;"—this sentiment, without further parenthesis, leads us at once to our inspection of the process of cutting some of those same teeth, and by an almost inevitable attraction, back to Birmingham, where we are standing at the door of the TOLEDO WORKS of Mr. Charles Reeves, manufacturer of smallarms to the trade and her Majesty's War Department.

Through this entrance, and up a flight of stairs, we reach the counting-house, and are at once placed under the guidance of the manager of the works, who conducts us by two or three warehouses where rifles and muskets stand in solid squares, as though upheld by ghostly infantry "grounding arms," into a series of somewhat narrow and, truth to tell, rather disorderly-looking yards, where iron in rusty piles, and scraps of metal in broken heaps, bespeak the presence both of raw material and refuse. Being anxious to begin with the incisors, we learn that the trade of Mr. Reeves includes almost everything which can in any shape be used for warlike purposes—that is to say, swords, cutlasses, bayonets, rapiers, boarding-pikes, hatchets, "matchets,"

tomahawks, scalping-knives, Malay creeses, and half a score other weapons whose names and purposes are more or less known. The staple manufactures in this branch, however, are the various descriptions of swords, bayonets, and "matchets," the latter being a sort of cross between a gigantic carving-knife and almost straight broad cutlass, fitted with a short handle, like that of a dinner-knife, and used by the native African and other tribes for chopping the sugar-cane, cutting through the jungle on their journeys, or for less amicable purposes. So great is the demand for these weapons that hundreds of dozens at a time are ordered to be delivered, afterwards to be bartered with natives for palm oil and other products, and it is noticeable that many of the handles are so small as to be entirely covered by an ordinary British fist, since they are intended only for the slender fingers of wiry aborigines.

The steel from which the swords are made is supplied (by Mr. John Sanderson, of Sheffield) in long pieces somewhat tapering at each end, and having a square portion in the middle, which, being cut through, leaves material for two blades, the bisection of the square leaving a shoulder at one end to receive the iron "tang" by which the blade is afterwards fixed into the handle. The manufacture of these blades is almost entirely effected by the forgers, who hammer them into the required shape upon the anvil, a mould running down the centre of which secures the hollow which in swords extends for about two thirds of the length from hilt to point. In a little street of smithies the musical clink is being sounded by a score of stalwart arms, either forging the rough steel into form or hammering the formed blade into perfect shape and symmetry, an operation which requires it to be kept at a certain heat lest the embryo blade should be injured in the process. Once perfected as to proportion, the hardening commences, and the blade is thrust backward and forward into the furnace until it has acquired a proper and uniform heat, at which point it is removed and instantly plunged into cold water. This process, which has obviously suggested the Turkish bath, renders it hard indeed, but at the same time so extremely brittle that we whisperingly suggest the propriety of contracting to supply our enemies with weapons and neglecting to carry them beyond that particular stage of preparation when they may be snapped with the fingers. Carefully supported, however,

the blade is again subjected to the fiery ordeal until it attains a slaty-blue colour and a beautiful and elastic temper, which has been partially secured by the previous hammering. By the process of forging it has become about six inches longer than the pristine steel shape, and by the tempering it has attained a springy strength which enables it to be bent in a curve sufficient to bring the hand five inches nearer the point.

Many of the best bayonets are forged in the same way as the sword-blades, and, as in almost every manufacturing process human intelligence has an unmistakable advantage over mere mechanical force, these possess some superior qualities. The greater number of bayonets, however, are made (by peculiar machinery patented by Mr. Reeves) from a square bar of drawn steel five inches and a half long by nine sixteenths square. This bar is passed between a series of about sixteen pairs of rollers, which are worked by steam power, and so grooved as gradually to mould the blade to the requisite shape. Sixteen times the short steel bar undergoes the merciless pressure of a progressively-increased power until its five and a half inches of length is increased to twenty-six inches, when some portions is cut off from the point to leave it the regulation length. During the late Russian war this machinery enabled Mr. Reeves to supply the government with almost incredible numbers of these weapons.

The matchets, which are made from bevel-edged steel passed twice through the rollers, are cut into the requisite shape by means of powerful shears.

These operations are conducted in a large shed, where the rollers stand like awful combinations of infernal machines and patent mangles; where a boding and vengeful tilt-hammer, worked by steam, is tended by a man, who sits like a calm fate beside its crushing bulk and supplies it with fresh victims; where the awful boom seems to shatter the very atmosphere, and deafness reigns triumphant. In obedience to a signal, however, the monster is suddenly stopped, and we are enabled to hear that the great two-pot furnace on our left is used for making the steel from those long laths of bevel-edged iron stacked against the wall; that the furnace is constructed with wide flues on each side and under the bottom, while the firegrate occupies the centre between the two pots; that the pots themselves are

some four feet deep and two feet and a half wide, are air-tight, contain layers of charcoal and iron covered with loam sand, will remain seven days and nights in the furnace until their contents are white hot, and that at the end of the time the iron will have been converted into steel of a slaty-blue colour. The inexorable hammer resuming its work at this point, we follow the bayonet to its completion, and once more visit the forges to witness the "shutting-on," or welding the blade to a piece of iron which ultimately forms the socket by which the bayonet itself is fixed on to the barrel of the rifle or musket.

There is yet another operation before the blades are taken to the finishing-shop, one of the most important, too, since it is no other than grinding, a process which secures an exact and uniform thickness, and increases their elasticity.

We are standing at the open end of a long, vast, and gloomy shed-like building, supported by iron pillars. On each side through the entire length a series of enormous grindstones spin round amidst sand and water and the mud from both. Seated astride the bodies of wooden horses, whose heads seem to have been transformed into these wheels, the grinders seize upon the blades, and each fearless rider, rising in his stirrups—or, what looks much the same, standing tiptoe till he no longer touches his saddle—throws himself forward, and presses the sword, matchet, or bayonet on the wheel, at the same time guiding it deftly with his left hand till its whole surface has been smoothly ground.

Along the whole line of whirling stones fly the lurid red sparks; and as the grinders, with squared elbows, seem to curb the struggling and impetuous wheels, we think of the wild dreams of Callot or Doré, and fancy a double rank of riders bestriding horses strangely foaled by some hideous nightmare.

After polishing, which is completed by wooden wheels bearing a coating of leather covered with emery, the swords and matchets go to receive handles, and the bayonets' locking-rings. The handles of swords are made of walnut-wood covered with the skin of the dogfish, while the hilt and guard are formed from a plain flat sheet of steel, in shape not unlike one side of a pair of bellows.

The solid socket of the bayonet is hammered into form and afterwards stamped into shape with the rim complete,

from which process it is conveyed to a shop where it is drilled by steam power. It then only remains to secure a smooth surface by means of a revolving barrel containing an instrument with a number of flanged blades, against which the socket of the bayonet is pressed. It is not a little remarkable to see the solid steel pared and shaved like wax, and no less wonderful to notice the simple machinery by which it is accomplished. The locking-rings are stamped out by a lever and die, pierced by a punch, and afterwards "bored," "faced," and their shapes secured by a triple circular saw worked by a lathe.

The most important manufacture in the Toledo Works, however, is assuredly rifles, and, with the intention of following it through its principal processes, we return to the vicinity of the still inveterate hammer, where we are shown a rudimentary barrel in the shape of a slab of best wrought iron (the iron used for this purpose being that which is made by the celebrated firm of Marshall and Mills), twelve inches long, and weighing nine pounds and a quarter. This uninviting slab is heated in a furnace and roughly bent into the tubular shape by means of our enemy, the tilt-hammer, after which it is once more placed in a furnace of an enormously high temperature, with a small trap-opening. When sufficiently heated, the short rudimentary tube is taken out on a long, round iron rod, fitted with a hand-guard, and looking like a gigantic burlesque rapier. This rod approximates to the size of the intended bore of the barrel, and is inserted with the rough tube upon it between two steam-rollers, each of which is furnished with a series of corresponding grooves or cuts. The barrel, which is taken up at one end by a rod, is placed between the first pair of grooves, and as the rollers revolve is drawn out at the other side a long, hollow, welded tube. This much more graceful and better-formed tube is then consigned to another rod of smaller diameter and to a corresponding pair of grooves, until after the eighth repetition of the same process the barrel has attained its proper dimensions. The next operation, which is called "lumping," consists of welding a piece of wrought iron on to the breech-end of the barrel, for the purpose of forming the percussion-lump, and is succeeded by "rough-boring." This is accomplished by a long, sharp-ended "bit," which being placed in the end of the barrel, revolves at the rate of perhaps a thousand turns

a minute, by means of a pulley and flywheel, while the barrel is pushed on by a lever, and kept cool by means of water thrown upon its surface.

The "setting" of the barrel is next effected by means of hammer and anvil, the "setting" meaning simply rectifying any bend which it may have received during the previous operation. We are not a little interested in the setting, since the first intimation of it on entering the shop is the sudden discovery of a number of workmen gazing resolutely at an opposite window through what look like attenuated telescopes. They are engaged, however, in one of the processes which require the greatest experience, as each of them is expected to detect the most trifling bias in the barrel. The "spilling-up," or cutting the inside of the barrel to the proper bore, is similar to the "rough-boring," except that only one edge of the bit is allowed to operate, the others being sheathed by a half-cylinder of wood called a "spill;" this ensures a smooth surface, and prepares for the "fine-boring," which is six times repeated, the final surface being ensured by keeping one edge of the "bit" perfectly smooth, by which means the particles of steel drop in a fine and almost soft powder.

The outside of the barrel is next turned in a long lathe, which not only reduces the roughness, but, by a beautiful arrangement of cutting tools, gives it the required substance, or "pattern," for a light or heavy rifle.

The grinding of the barrels is effected by means of stones larger than those used for the swordblades, but in a similar manner, and is preliminary to "filing," which carries the barrel to the shop where it is prepared for the lock.

These preparations consist of "chambering," or making the chamber which holds the pin; "breeching," or cutting the worm intended for the breechpin that helps to hold the barrel to the stock by means of a breechnail; cutting out the little slice into which the "sight" is to be dovetailed; machining the lump, filing the tailpin, and making the square lump the proper shape for receiving the lock and stock.

We are not a little surprised to learn that every part of the lock is finished by hand, the cock being cut with a die worked with a heavy weight, and the smaller pieces being wrought with forge, hammer, and file.

The great art in lockmaking is to obtain a perfect spring,

and those properly tempered are so elastic that although, when fitted in the lock the two sides are so close as almost to touch, they will, when released, spread to two inches below the edge of the lock-plate. The lock and barrel are now ready for the stock, which awaits them in another shop, where it has been sawn out of walnut-wood, and finished by carpenters' tools.

The barrel let into its groove, and the lock properly in its place, the stock is more perfectly shaped and rounded before the "screwing together," or the addition of the different parts of the "furniture"—heel-plate, trigger-plate and guard, trigger, nosecap, rod, and bayonet. We are now told that the rifle is "finished," by which understanding *completion*, we are not quite prepared to learn that it is to be taken to pieces.

We suddenly remember, however, that it is not yet a rifle at all, inasmuch as the barrel has not been rifled. Everything is made perfect before this delicate operation is attempted, in order that no injury may be sustained by the barrel when the complete rifle is again put together. The process of rifling is similar to that of boring, except that a spiral cutter is substituted for the "bit." Previous to the reunion of the barrel, the whole work is polished and the stock stained and finished ready for completion.

The pistol-barrels undergo the same processes as that of the rifles, except that, after being drilled, they are "planed" by machines, which carry them along a sort of bed under tools that cut them perfectly smooth and accurately shape the octagonal barrels. These chisels move by means of screws over the entire surface as it is drawn backwards and forwards on the slide.

The revolver chambers are drilled out of solid iron by a drilling-machine or lathe, with a centrebit and an eccentric motion, which causes each barrel of the chamber-nest to become the centre in succession, while by means of a slide the motion can be made to suit either a large or small chamber. The recesses communicating with the lock and trigger are cut by reversing the chamber in the eccentric "chuck" and using a different cutting tool, while another alteration effects the drilling of the nipple-holes.

In returning to the warehouses we discover that we have omitted (with no unpacific intention) inquiring after the scabbards of the "trusty blades" the progress of which we

have been watching with so much interest. They are being made, however, close by, so that we speedily learn how the thin sheets of iron are marked to the pattern and cut into the required shape by shears—how they are bent at the vice round templates or mandrils, the edges having been beaten thin and flattened with a mallet—how, a shape having been slipped into this rough metal sheath, the edges are lapped over at the vice and soldered at the forge, the perfect shape being afterwards obtained by means of the hammer; how it is fitted with the "bands," and the "drag," filed, supplied with a mouthpiece, polished; and finally lined with thin strips of deal or with solid leather.

Beside his extensive manufacture of rifles for the government and the production (as licensee) of the Whitworth rifle, Mr. Reeves has introduced important inventions of his own, amongst the most prominent of which are the double action revolver and his patent rifle. The former weapon is so constructed as to secure greater strength in that generally overtried part of the revolver against which

contiguously, will fire under water, can be loaded with wonderful rapidity, and is provided with a safety-bolt which

The patent rifle combines both the ordinary muzzle-loader and the breech-loader, has the advantage of being an unjointed rifle, and can be loaded and fired nine times in a minute without difficulty.

In the warehouses through which we pass on our way out, stand weapons in every variety and with every degree of finish—from the splendid dress sword of the full blown officer or the rapier of a courtier to the heavy cutlass of the sailor, or the "matchet" of the African savage. Close to a stack of muskets sold by the dozen, is a rifle whose exquisite finish and perfect appointment would command more pounds than would serve to buy weapons for a negro body guard. Of what may be effected in the way of beauty of finish in a plain and soldier-like rifle, the visitors to the Great Exhibition who saw Mr. Reeves' Whitworth, long Enfield, and short Enfield, were able to judge; while the splendidly chased revolver, with its gold arabesques, and white steel barrel, displayed the more ornamental features of the manufacture. Of this, however, a still better example was that magnificent sword with wonderful damas-

cening on the blade and exquisite Italian work in oxidised silver ornamenting the gold ground of hilt, scabbard, and guard. Amongst the various specimens from the Toledo Works this seemed to be the most elaborate; while, perhaps, the most curious was a marvellously elastic blade coiling itself in its serpentine sheath, and which, on being withdrawn, leaped in the hand a straight and springy wand of glittering steel. The Toledo Works cover a large extent of ground. The machinery, of a very complicated and costly kind, is set in motion by steam-engines, equal in power to 150 horses, and upwards of four hundred artisans are employed, many of whom form part of a gun-makers' company of volunteers, of which Mr. Reeves is captain.

WEIGHBRIDGES, AT THE ALBION WORKS OF MESSRS. POOLEY AND SON, LIVERPOOL.

THERE could be no better illustration of the enormous advancement made by British commerce during the past century than the particulars involved in the history of the rise and progress of Liverpool. Since 1719, when the first wet dock was formed on the site of the old pool, or haven, till 1761, when the third dock was completed and the outer harbour was secured by piers, Liverpool continued to grow to the full proportion of a large commercial town. It was after this period, however, when the United States of America had sprung into a complete national life, that the trade with which they have ever since been so intimately connected, fostered the prosperity of this magnificent seaport, and transformed it almost into the commercial capital of Europe. In the forty-five years which ended in 1837, the possessions of the corporation had been doubled, and at that time amounted to £3,000,000. There is probably no sight in the world which could give the visitor a more complete notion of the stupendous trade of Great Britain than those six miles of granite docks which line the shores of the Mersey on the Lancashire or sweep inland on the

Cheshire side—than those enormous piles of warehouses which flank the docks and quays. It is to the magnitude of these emporiums of trade that Liverpool owes her purely commercial reputation, while at the same time it has become customary to identify her entirely with trade to the exclusion of her claims as the seat of several large and important manufactures. It is to one of the oldest of these, however, that in the interest of English workshops we are about to pay a visit. Passing St. George's Hall, one of the most magnificent, as it is certainly the most complete and comprehensive, of our public buildings, we soon arrive at the Albion Foundry of Messrs. Pooley and Son, which established as ironworks in the last century by the father of the present senior partner, has several times changed its site, and finally settled down in its present position on the margin of what was once the old pool of Liver. Perhaps without sufficiently regarding the good or evil omen which is popularly supposed to attend the operation (especially when, as in our case, it is effected on a Friday), our first experience of the Albion Works consisted in being weighed. Indeed, the greater part of the business of this immense foundry is the manufacture of machines for weighing everything capable of being weighed. From an enormous weighbridge, constructed to receive and register the weight of a loaded railway-truck to the finest balance for determining the loss of the precious metal in a light sovereign, machines of all descriptions are perfected in this extensive range of workshops.

The introduction of the platform weighing-machine into this country is almost coincident with the practical inauguration of the railway system of transit, and dates somewhere about the year 1832. Prior to this time almost the only recognised mode of ascertaining weights, of whatever magnitude, was by an application of the scalebeam. Some time previous to this, however, the platform weighing-machine had been so generally adopted in America that it had in a great measure superseded the use of the scalebeam for the purposes of commerce. This fact having become known, a patent was obtained here in 1834 for a machine founded on the American principle, considerably modified, however, and greatly improved. A large machine, being an important modification of this patent, is still manufactured by Messrs. Pooley, on account of the facilities it offers for as-

certaining heavy weights under certain circumstances. The advantage offered by the weighing-machine in the first instance was the great economy of labour which it offered in comparison with the older methods, this economy being also combined with obviously greater accuracy of results. The vast increase of traffic introduced by the railway system of transport gave rise to a necessity for obtaining apparatus by which the weights of great quantities of goods could be ascertained with accuracy and dispatch; and to achieve this object Messrs. Pooley bent their energies and ingenuity with a degree of success which has resulted in rendering the weighbridge an indispensable adjunct of every railway station in Europe, and indeed throughout the world. Since their introduction, and encouraged by the great demand which has arisen for them, as well as stimulated by a desire to render the weighbridge, and indeed all weighing-machines, as perfect as possible, every means which ingenuity could devise has been sedulously adopted at these works to ensure the widest adaptability and the most perfect accuracy of result. The extent and importance of the improvements effected in this way will be in some degree illustrated by one or two of the machines which may be considered typical, and which we shall see presently in completing our tour of the premises.

In our ramble through the works, after leaving the sale-room, we are conducted to the draughtsmen's room, where, as is usual in all large works, drawings of the different machines and of their details are prepared on a scale large enough to work from. In close contiguity with this is the pattern department, an extensive and well-arranged shop, where the drawings are worked out to the full size in wood, and of the exact form which the metal is to assume in its finished state, but slightly larger, to allow for the shrinking of the metal as it cools. When completed, these patterns are handed over to the "moulders," an important class of operatives, who, securing the pattern, place it in the "moulding-box," a pair of strong metallic frames, having rims deep in proportion to their size, and their general surface being reticulated with iron bars, so that they bear some resemblance to a huge gridiron. The interstices between the bars are rammed full of sand ground from red sandstone and mixed with coal-dust; and the mould is completed in the manner already described in another page. At the

Albion Works, however, the moulding-boxes are of such an enormous weight, some of them reaching twenty tons, that they have to be lifted by powerful cranes. It may easily be imagined that the casting of these immense masses of iron is an interesting process, but it is by no means easy to convey the striking *ensemble* which it displays. When once the moulds are thoroughly prepared the twilight of the foundry is suddenly superseded by the red glare of molten metal, which, as it issues from the open sluices of the two great cupola-furnaces in the yard outside, is caught and conveyed in iron buckets lined with clay by a large number of men who bear the fiery liquid hither and thither to the various moulds. To the ordinary spectator the scene is one of some confusion, not unmingled with fear for his own personal safety; but, at the same time, throughout all the rush, and heat, and glare, and the coruscation of the brilliant stars thrown off by the incandescent stream, the men complete their work without a flaw or break, while the mighty cranes seem almost instinct with life as they seize and swing the awful cauldrons full of liquid metal in order to cast an iron platform, cylinder, or crane in one solid piece.

COAL AND IRON AT COALBROOKDALE.

Since the days of Tubal Cain, whose short but emphatic biography as the first instructor of artificers in brass and iron makes his name one of the most prominent in the history of mankind, the workmen of the forge and the foundry have been foremost amongst the pioneers of civilization. Ours may be called the Iron Age in a better and more universal sense, perhaps, than any other, since the metal which was once held to be the representative of stern reality and uncompromising warfare has become a material by which the sciences are developed and the arts find adequate expression in the beautiful variety of design which may be borne by common household implements in daily use.

It is to one of the greatest workshops of modern times, where we may see the glorious metal in both these phases of

its mighty existence, that we are bound; for at Coalbrookdale, iron as raw material, as manufactured metal, and in its adaptation to great engineering works, to exquisite ornamentation and to commonest domestic use, may be viewed in that series of factories which lie, one great workshop, in the bosom of the valley, where the landlocked pools from the broad Severn reflect the wooded hills.

With the necessity before us of a long day in "the Dale," we have passed the night at picturesque old Shrewsbury, full of dreams about the Mercian Saxons who gave it its name of Scrobbesbyrig, or Woodyhill—of York and Lancaster, of Falstaff and Shrewsbury clock, of rich cakes and fat brawn; and as we are carried by the railway to Ironbridge, we note in the grand old ruins of Buildwas Abbey, with its deep and tree-shaded fishponds filled with speckled trout, the relics of those "good old times" for which so many people lament.

Passing the beautiful table-land from which the Wrekin rises, grand, not stern, its green-clad crest lighted by the early sun, we enter the beautiful glen known as Coalbrookdale, whose embowered hills overlook the vale of the Severn, their neighbour the Wrekin, and his more distant cousins of the Malvern range, Herefordshire, and Wales. Here in the deep valley, where the monks of Wenlock (the ruins of whose priory still remain) held their rich preserves of fish and game, ironworks have been established certainly ever since the Commonwealth, while even in the reign of Henry VIII some records occur of a "smith-house" existing on the spot. In 1711, however, the germ of the present extensive works was established by the family of Darby, who became the proprietors of the district, and under their hands and those of their descendants, a large portion of "the Dale" has been sunk in mines and coal and clay-pits, and covered with brick-kilns, and forges, and factories, whence almost all the implements for which the casting of iron is a necessary process are sent not only to all England but to the most distant countries of the world.

Strangely enough, however, all this has been done without destroying the romantic aspect of the surrounding scenery. It may even be doubted whether it has not added another picturesque feature to the otherwise silent gorge where the trout still leap in the old pools, and come up readily to the well-cast fly.

It was at the Coalbrookdale Works that the first improvements in the manufacture of iron were carried out. Here, also, iron tramways first came into use, and the castings for the early engines of Boulton and Watt were made. Nay, we are now crossing the first iron bridge, which, constructed to span the Severn on a single arch of 100 feet, stands, apparently as firm as when it was first erected, at the expense of Mr. Abraham Darby, in 1779.

We have no time to linger, however, for the works extend for some seven miles 'round, and include brick-kilns, terra-cotta works (a new branch, but lately introduced), blast furnaces for making pig iron, puddling-furnaces, rolling-forges and rolling-mills, and the range of workshops where the immense operations in casting are now carried on—operations which include the production of those exquisite gates, ornamental stoves, and interior decorations which were so attractive at the Great Exhibition, and at the same time involve the manufacture of fryingpans and iron pots, which, indeed, under the general name of "hollow ware," formed the principal trade some two centuries ago, and is still a very considerable branch of the business.

Having been well accredited to Mr. Charles Crookes, under whose experienced management the whole of these works are conducted, we find an open carriage waiting for us, since the roads are somewhat steep, and a wet day has made them rather heavy walking. By these means, and under the valuable guidance of the manager himself, we are able to make a tour of the principal departments, even a rapid visit to all of which requires an entire day.

The first object which claims attention is a mill for grinding the corn for the workpeople—an arrangement which may be better understood when it is remembered that more than 3000 men, women, and children are employed by the company. The pretty little garden plots which are attached to the cottages in Lightmoor Valley are many of them freeholds belonging to the operatives themselves. Mr. Crookes informs us that these small holdings are encouraged amongst the people, and that since his residence amongst them, during more than thirty years, "strikes have been unknown."

Leaving these behind, we reach the great heaps of ironstone

in the vicinity of the mines—enormous mounds, upon the slopes of which the women and girls stand or kneel, hammering, sifting, and sorting the ore as it is brought to the surface. The whole hillside and the undulating platforms of tableland are broken up by the ruins of old pits, their former mouths inclosed in order to keep unwary passengers from their treacherous vicinity. There are at present more than forty iron and coal pits in process of working, and the great mounds of ironstone, "clunch"—of which fire-bricks are made—and a peculiar black clay found with the iron, but of no particular value, almost rival the natural hills which rear their wooded heights above. These are again superseded, however, by the mountains of furnace refuse, cinder, and slag which lie covered with the coltsfoot, here growing in luxuriant abundance, and showing rich tints of red and green and brown. The tramways from the mines supply the iron and coal to the furnaces towards which we are journeying, and the refuse brought from those furnaces accumulates till year by year the heaps grow larger and make fresh artificial hills scarcely less verdant than the natural eminences beneath which they are formed.

From the mines on our way to the great blast-furnaces, we pay a short visit to the brickworks and tile-kilns, where a large business is done in bricks and tiles of all descriptions, made from a superior kind of clay found on the spot. The completeness of these works very far exceeds any ordinary brickfield, since the operations are conducted under well-built covered sheds, and even the men who attend the kilns are sheltered by an arch which protects them from the wet and the keen winds, both matters of no little importance on these Shropshire slopes. A number of boys and girls are employed on these works; but to the factories belonging to the company a school is attached, and no children are admitted to work until after the age of twelve years, or unless they have previously received some education. One of these schools, which we shall presently pass—near Horsehay—is a really fine structure, looking like a nobleman's mansion, and they are all under government inspection.

Near the brickfields, the terra-cotta works have recently commenced operations. Some of the productions of this department were shown at the Great Exhibition, in the department with Maw's tiles; and here we see in the clean

modelling-shed some of the same vases and flowerpots and storebacks as were there displayed. We noticed, too, some of those beautiful mignonette-boxes which resemble carved wood, and are, perhaps, amongst the prettiest of all the adaptations of this branch of plastic art.

Just outside these works another huge heap rises: it is composed of clay taken from the spot, weighs some 25,000 tons, and will be used for fire-bricks.

The blast-furnaces stand in the more open country, so that we leave the rest of the works behind on our way to them. Very strange and almost terrible they look—their blackened shafts reared like grim old beacon-towers crested with fire, whilst between them the verdant sweep of country, hill and vale, smiles under the noontide sun. There are seven of these blast-furnaces, some of them the oldest in the country, and one devoted to that fine, grey iron, peculiar to the Coalbrookdale Company, of which this furnace will turn out 120 tons a week. Up to the very feet of these fiery monsters the green coltsfoot trails its broad, downy leaves; and it is a wildly picturesque spectacle to see in the gloaming of an autumn night the opening of the furnace-tap through which the liquid iron comes lapping into the channels of sand, running into the trough which forms what is called "the sow," and so branching off into the shorter bars which represent "the pigs." Lighted up with a red glare, the brickwork, the face and bodies of the half-naked men, as they stand reeking by the flood of fire, and the tall shafts with their blazing crests, stand in forcible contrast to the darkening valley and the distant uplands where the dun September night is falling.

It is necessary to follow the "pigs," however, in their journey to the works at Horsehay, where they go to be manufactured into bar iron of various qualities, the company's annual manufacture of this material being about 18,000 tons. Here, in a large area like an immense open shed, where we are surrounded by the din of wheels and hammers and the glow of fires, we are introduced to the puddling-furnaces. Of these there are about thirty-five at work, and within their fiery jaws, the bottoms of which are lined with a sort of calcined clay mingled with iron slag, and technically called "bulldog," they receive the "pigs," about four hundred-weight at a time. As the pig iron melts, the puddler at the mouth of the furnace continues to

stir it, with a long iron rod bent at the end, until it becomes of a sort of pasty consistence. Before it arrives at this state, however, it has boiled, and by that means thrown off the carbon, so that the puddler is able to collect it together in the form of four or five large balls, which are received into iron trucks running on a tramway and carried to the shingling-hammer, an immensely powerful hammer worked by steam power. This reduces it to a short square ingot, called a "bloom." This "bloom" is next carried to the rolling mills—large horizontal cylinders or rolls, scored with variously-sized grooves, and between these cylinders the "bloom" is squeezed and lengthened into a forged bar. Each of the puddling-furnaces will receive 25½ cwt. of pig iron in the twelve hours, from which about 23½ cwt. is obtained for the manufacture of bar iron.

At the rolling-mills the iron is again subject to the pressure of revolving cylinders of enormous power. To these we see the white-hot slabs carried on the iron trucks, seized by the attendant workmen with their long tongs, and caught with the utmost precision by the rollers, from between which it ultimately comes forth a great broad plate of iron. As it is drawn between the rollers, the enormous pressure spurts the soft and almost liquid surface of the hot iron in a fiery shower—a fact of which we are reminded by the sudden pattering upon our hats of a few drops of this red-hot rain, to see the cause of which we had ventured into the direction whence it was thrown.

We should like to stay and listen to the stories of those herculean men who are standing at the hammer, to learn something of their habits, their immense strength, and their possible earnings, but the largest portion of the works have yet to be visited, the largest because of the variety of the manufactures it includes.

Once more towards the starting-point, then, to see the process of casting in all its branches, from the enormous plates which are being riveted to the framework of that great iron bridge constructed for the Severn Junction Railway—one of the largest spans yet made for the same purpose, and which will cost thousands—to the three-legged iron pot destined to swing above the fire in an African encampment, and which is sold for tenpence. The first operation towards casting is, of course, designing; and here, in a light, clean room, close to the brookside, the designers

are at work with wax and plaster. A most artistic gas branch for the station of the Underground Railway is at present being modelled on a board, and surrounding the room are several of the designs which have already become popular. From the designs are made the patterns in wood, iron, and white metal. The making of these occupies a long range of buildings, in which a large number of men are employed. The Coalbrookdale Company, indeed, keep a greater variety of patterns than any other manufacturers in England.

Going out into the yards where the principal casting-houses are built, we become somewhat confused amidst stacks of pig and piles of scrap iron, furnaces, machinery, and all the appliances of an enormous factory. Here the cupola-furnaces receive the pig iron used for the various descriptions of casting, and the portable iron pails carried like a sedan-chair are continually coming for a fresh supply of the metal-stream, and going with it to the casting-houses. Amongst the furnaces is one now disused blast-furnace, which, like the organ of a parish church, bears the date of its original erection, 1658, and its subsequent renewal by Abraham Darby in 1777.

It would be impossible within these limits to give any detailed description of the various processes of casting, including the beautiful manipulation by which the sand-moulds are prepared with reverse sides, and the "cores" for hollow figures. The moulds are boxes of a peculiar description of sand into which the patterns are pressed, and so one side of the work obtained; the other side is similarly prepared, if it is intended to make a solid casting. If a hollow casting is required, the mould is prepared with a hollow pattern, into the impression made by which a solid "core" fits, leaving between the surfaces a space equal to the thickness of the metal. When the two boxes, or the mould and its "reverse," are brought together, the liquid metal is run in, passes through small channels in the sand left for the purpose, and the casting is complete.

If it is difficult to describe the process, it is certainly impossible to enumerate the different articles in course of manufacture. Gates, chimney-pieces, doors, stoves, ranges, garden seats and chairs, green-houses, fenders, gas-chandeliers, and brackets, gas and hot-water apparatus (for which the company have a high reputation), hat and umbrella

stands, vases, card-baskets, and a hundred articles of mechanical, architectural, scientific, or domestic use, are being made every day and all day long. We are fortunate in seeing a pair of magnificent gates, in their various stages, one gate having just been cast, and the moulds for the other being just completed. The pattern is about to be lifted, and as it is removed piece by piece from the mould, the form of scroll, and stem, and flower is left with extraordinary precision and sharpness in the evenly-prepared and firmly-compressed sand. The casting is so clean and perfect that not a speck or a defect can be detected in it, although it lies there untrimmed by chisel or file. It weighs nearly a ton, and is the largest piece of casting of an ornamental character ever produced in this country without a flaw.

Desiring to see the manufacture of a frying-pan, we are taken to a large building where this department is carried on, and are not a little surprised to discover that the mould for this useful article is made in a manner precisely similar to those of more pretensions—that it requires nearly as large a degree of skill; still more to mould the iron pots, of which, with their humble neighbours, thousands are contained in an immense warehouse, piled from floor to ceiling. Water power is very largely employed at Coalbrookdale for the heavy engines, including some of the great lathes used for turning the iron, but a considerable adaptation of steam power is also required for the various descriptions of machinery.

The fitting-shops receive the smaller castings, and here all their parts are properly fitted together: while in the chasing and bronzing rooms that exquisite ornamentation for which these works are celebrated is carried on by a band of skilled artisans. It will be remembered that for the finer description of ornamental castings the company gained a council medal in 1851, and that they also received a medal in Paris for their process of electrotype bronzing, which secures not only a beautiful appearance but astonishing durability of surface. From the photographic studio in which pictorial records of the elaborate designs executed on the works are preserved, we are compelled to turn once more towards Ironbridge, on our way back to Shrewsbury. Not, however, without admiring the church (built by the Darby family), whose beautiful peal of bells must sound with peaceful effect as they chime over the dale where the busy work-

shops lie in Sabbath stillness—not without a rapid visit to the handsome structure (which stands so well as the companion of the sacred edifice) where the Literary and Scientific Institution is conducted. This building, which was erected from the designs and under the direction of Mr. Crookes, is, indeed, one of the most complete ever seen, and contains, besides a handsome and spacious lecture-hall, with a fine gallery and commodious platform, a reading-room and library, various smaller apartments, and a well-appointed studio, in which the members are taught drawing by a thoroughly competent master. The collection of models, casts, and studies are of the very best description, and, to judge by some of the drawings executed by the pupils, are thoroughly appreciated, and must have a marvellous effect in the cultivation of that artistic taste amongst the workmen for which Mr. Crookes himself possesses no small reputation. With the pleasant impressions of this eminent social institution, and of the benefit which it is calculated to convey to the *employés* of the Coalbrookdale Ironworks, we heartily shake hands with the energetic manager and take our departure.

A CANISTER MAKER'S.

Leigh Hunt—who once wrote a charming essay about a common pebble, and whose light and graceful fancy imparted almost poetical associations to so many of the commonplaces of our London streets—has described, in his happiest manner, the interest and pleasure which a thoughtful observer may derive from the contemplation of an ordinary shop-window. Naturally enough, he chiefly dwelt upon those shops which we connect at once either with the freshness of Nature or with the efforts of Art: upon the fruiterer's shop, with all its wealth of pine and melon, of strawberry and peach; or upon the shop of the print-seller, from whose windows the lovely faces that filled the imagination of Titian and of Raphael still smile forth upon us with their eternal beauty. Whilst touching, but slightly, however, upon some other shops, which it was difficult, if

not impossible, to invest with an equal interest—and to several expressing an absolute dislike and aversion—he has emphatically praised the shops of the grocer. It is to be regretted that he did not describe it more fully. What writer could so gracefully have led the reader on with him, as he descanted upon all the associations which the shops of this trade so readily suggest—associations which range from the fables of the 'Arabian Nights' to the essays of the 'Spectator.'

Most of us can remember with how much interest, in our childhood, we were accustomed to gaze upon the grocer's window, and with what wistful envy we contemplated the grocer's assistants, those thrice fortunate beings who lived and moved in an atmosphere charged with sugar and treacle, with apparently no restraints to prevent their perpetually indulging in those luxuries, our own supply of which was so harshly regulated by older hands. With its figs, dates, and raisins so temptingly placed within our very reach, and yet so difficult of attainment, the place seemed an absolute treasury and store of all things luscious. Nor, whilst our palate was thus appealed to, were our eyes without other wonders to charm them. Specially were we attracted by that long row of canisters that lined the grocer's shelves, some simply bearing their plain numbers inscribed upon them, but others brightly burnished, glittering and glowing with colour, and adorned by those strange and quaint pictures of Chinese life which combined with the old-fashioned cups and saucers to form our boyish ideas of the mysterious dwellers in the Celestial Empire. It is of these canisters that we are now to speak, in the hope that some account of their manufacture may not be without interest to our readers, as an inspection of its processes has assuredly not been without interest to ourselves, during a recent visit to the "Hardware Village."

Birmingham,—which drives a thriving trade alike by supplying domestic wants, and by ministering to foreign superstitions,—Birmingham, which, at a moment's notice and with impartial skill, will undertake to provide either the furniture of a lady's work-box or two dozen idols for Hindoo worshippers,—Birmingham, which is equally great in *papier maché* and in polytheism, and which includes amongst its countless trades the manufacture of *thumb-screws*, Birmingham, producer of buckles and of buttons,

of pens and of pistols, of thimbles and of toys, has plenty of other things to depend upon besides the construction of our canisters; but, in this branch of trade, as in so many others, she holds her own. Accordingly we experienced but little difficulty in meeting with a manufacturer (Mr. Ludlow, of Smallbrook Street), who kindly accompanies us through his works, and gives us such explanations as are necessary.

Let us first speak of the raw material, tin. It lies before us in boxes, each containing from about 120 to 200 thin sheets, varying in size from fourteen inches long by ten deep, to twenty inches long with a depth of fourteen. Our "raw" material, however, we need hardly state, has already had a long and interesting career. From its home in the Cornish mines, whither the old Phœnicians came to seek it 3000 years ago, it has been extracted; it has then been dressed so as to separate it from its accompanying earthy matter; it has been pulverized and "stamped." As tin ore can be made to yield from 50 to 60 per cent., it requires a degree of attention and a delicacy of manipulation far greater than most other ores demand. After being smelted, either by exposure to the heat of pit-coal upon the hearth of a reverberatory furnace, or, should still greater purity be required, by being fused in a blast-furnace, in which wood-charcoal is used for fuel, it is applied by the process of "tinning" to other metals harder than itself, and now becomes fit for our purpose.

Taking a sheet of tin with him as a kind of "working model," one of Mr. Ludlow's men now invites our attention. He commences by ill-using the same tin-sheet, by belabouring it violently, and knocking it ferociously with a heavy mallet, he beats it out into a semi-circular shape, which even our own uninitiated eyes speedily recognise as being that of our canister's upper story. Very little peculiarity or speciality of mechanical appliances does he require. It is chiefly upon manual skill and the dexterity that springs from constant practice that he has to rely. His tools are but few, and are mostly very simple. They consist of bench-shears and of hand-shears, of mallets and of hammers, of steel-heads, and of wooden blocks, of soldering-irons and of swages. With his shears he now cuts the plates required for the body of our canister, into their proper size and shape; making them fold and lap over at the

edges, he joins one plate to another by simply uniting these edges, and then soldering them together. The edges are themselves made, we should observe, by placing the sheet upon the bench, and beating it with a hammer. Our canister now begins to assume form and consistency. We strengthen him by binding thick iron wire round him, which we dexterously conceal by further manipulations with our hammer; we groove him with our groover, we cut his bands for him with our roller, we give him any necessary beading by our "swages:"—bottom and top, we have folded him, and edged him, and over-lapped him, and wired him, and soldered him. As far as our own share of the work goes, we have done with him. He stands before us, a white and comely canister to see.

As to the size of these canisters, they range from the small ones, capable of containing only six pounds, to the stately "store-canisters," which will hold two hundred and twenty-four pounds, and which measure forty-one inches in height by twenty-five and a half inches in diameter.

Having been thus built up, it remains for our canister to be decorated. He is mere tin at present, white and clean, no doubt, but devoid of any special beauty. We must send him to another room, where he is received by women, who immediately clothe him in emerald green. He looks much gayer after the process, but is, of course, somewhat blotchy and flaky as regards his complexion. He must be placed in the stove, where we leave him for the night, to dry.

When another morning breaks upon the somewhat smoky horizon of Birmingham, we revisit our canister, and find him dried. He is very rough, however, and seems to have passed a night of considerable suffering; so we send him to another room, where some more women receive him. Armed with large quantities of pumice-sand, they seize upon him and give him a thorough good scrubbing. Blemish after blemish, blotch after blotch, they assiduously remove; his coat of green becomes even and smooth, though it still looks rather crude. The ultimate and decisive process which shall make him a "thing of beauty and a joy for ever"—which shall concentrate upon him the admiring gaze of childhood, and inspire some interest even in older breasts—this process, which is more than handicraft and scarcely so much as art—has now to commence. Far daintier hands does it require than any of the work which we have hitherto mentioned,

and it is remunerated accordingly. Whilst the women who scrub our canister only get from ten to twelve shillings a week, and whilst the workmen who build him up are paid from twenty-five to thirty, the "ornamenter" obtains from thirty-five shillings to forty. It is only fair that this should be so, as an apprenticeship has to be served; and as the work requires, not merely delicacy and patience, but also a considerable knowledge of design. Indeed men have risen, more than once, from such occupations in Birmingham, to become professional artists of distinction.

In the ornamenter's room the canister now stands; the ornamenter or japanner accordingly sets to work. A brief account of the process must suffice. The ground having been prepared, the desired colours are applied with a brush; they are chiefly flake white, Prussian blue, vermilion, Indian red, king's yellow, verdigris, and lamp black, whilst any other gradations of colour that may be judged necessary are produced by combinations of these. The perfected painting may certainly sin against the laws laid down by Chevreul "On Colour;" its end and aim have been the brilliant, rather than the chaste, glittering, gorgeous, golden, it has to strike the eye, not to soothe it; and as regards the design, it is often as incongruous as the colour. Sometimes, indeed, the painting is copied from authentic sketches of Chinese or Japanese life, and, notably, from engravings of that sort that have appeared from time to time in the pages of the 'Illustrated London News,' but in very many cases the japanner is himself his own designer. Of course, his designs are chiefly conventional. Mr. Ruskin would probably indulge in violent language if some of these productions were submitted to him for his critical opinion; and yet we are bound to bear testimony to the talent and taste that some of them display. As is the case with everything relating to Chinese, they are chiefly comic, intentionally or not. It is impossible to take the pig-tailed people *au grand sérieux*. With their winking little eyes, and their silly little feet, and their meagre little beards, and their diminutively monosyllabically tantalisingly, and essentially funny little language, you cannot help laughing at them,—whether, like Sir Hope Grant, you have to scatter their absurd armies by charges of cavalry, or whether, like our friend the ornamenter, you have merely to paint them on varnish and gold. So they *are* laughable

most of them, vapid little women simpering with deliberate vacuity of facial expression upon as vapid and as vacuous little men, on the margin of unmeaning lakes, where boats without an object float drowsily on to nowhere in particular, sit these damsels, simpering on these swains; musical instruments do they sometimes play, looking the while as if they felt a kind of comic dignity in not listening to their own tunes; tea do they quaff, in various ways and from various vessels, but vacuously and vaguely still. Meanwhile, all about them are vermilion and gold, and the brazen lustre of impossible sunsets tips unmeaning hills with a burnished splendour, to fill up a background for the insipid scene. However, as we have said, some of these productions are decidedly highly creditable to the artist workmen engaged.

Whatever degree of ornament our canister may now have received,—whether he has been decked with an elaborate painting, or has simply been inscribed with his number,—a few processes yet have to be applied to him. The painting being finished, and great care having been taken that it is thoroughly dry, as many coats of varnish are passed over it with a brush as the workman thinks necessary to enable it to bear polishing. The stove, at a temperature of 70°, is again used at this period. After a night's hardening, the canister is ready to receive his finishing touches. Taken from the hands of the ornamenter, and entrusted again to those of women, the final polishing takes place. Rags are dipped in rotten-stone, and freely rubbed over the varnish. Brighter and brighter grows the canister after his long probation; more and more effulgently do the crimson and gold flash out upon the sight; he is as bright, you would say, as all the rotten-stone in Europe can make him. Perhaps you are right; nevertheless, *one* other process still remains. To give him his final touch rags will not suffice, and rotten-stone is worthless; a far more delicate pressure must be laid upon him.

The women who apply for employment in this interesting branch of British industry are invariably asked, as a condition precedent of their engagement, whether they have *soft hands*. Your soft hand is—as Shakespeare says of your gentle voice—an "excellent thing in woman;"—and in this peculiar instance we perceive that it has an actual and substantive monetary value. For now, with the most dexterous

twist of the softest hand, is our canister gently rubbed; nothing more has he now to endure; serene and beautiful, he is placed upon a shelf where, in the company of other canisters as radiant as himself, he waits until a purchaser appears.

FITZROY ZINC AND GALVANIZED IRON WORKS.

ZINC was, up to a comparatively recent period, one of the least important metals with regard to its application in the arts and manufactures, though well known since the Christian era as one of the two constituents of the important alloy brass. Of late, however, certain excellent properties possessed by this metal, and its comparatively low price, have led to a more extensive use of it for a variety of purposes, and especially as a substitute for lead and tin.

Zinc is a bluish-white metal, which slowly tarnishes in the air, but only superficially, the film formed on the surface effectually protecting the metal from further oxidation. Its specific gravity varies from 6·9 to 7·2. Though naturally very brittle, it may easily be rendered quite malleable and ductile, by being subjected to a process of lamination, at a temperature of from 220° to 300° Fah.

The principal ores from which the metal is obtained are, the sulphide of zinc, more familiarly known as *blende;* the silicate, which is called *calamine;* the carbonate, or *sparry calamine*, and the red oxide, or *zinc ore*. These ores are found in abundance in England in many localities, as in Cumberland, Derbyshire, Cornwall, Flintshire, &c.; but zinc is also largely imported into this country from abroad, both in the ore (calamine, for instance, from Spain and the United States of America) and in the metallic state, either crude in cakes, or rolled out in sheets, principally from Germany, Holland, and Belgium.

The entire consumption of spelter throughout the world may be estimated at present at above 70,000 tons per annum, of which about 45,000 tons are used in the form of rolled sheets, generally from 7 to 8 feet long, by 3 feet in width, and of various gauges of thickness, from No. 6 to 16, *i. e.*, from about 0·025 to 0·072 of an inch.

The Fitzroy Zinc and Galvanized Iron Works, carried on by the firm of Messrs. F. Braby and Co., are situated in the Euston Road. The entrance is by an archway from the street. After passing through a yard, we are ushered, by the proprietor of the Works, through a door on the left, into what is called the "Perforating room." Here we find three powerful machines for perforating sheet-zinc, copper, and iron; two of them actively at work. It appears that the perforation of metals, &c., forms an important branch of Messrs. Braby and Co.'s business. The one of the two machines is just working off a large order for one of the leading tin-plate workers at Birmingham; the other is punching a new pattern, quite recently introduced, through an apparently endless succession of sheets of zinc. The sheets perforated with this pattern, which, by an ingenious combination of the oblong with the round and club, gives a very large area of perforation, without much lessening the strength of the sheet, and admits, accordingly, of the employment of the lower gauges of thickness, are intended principally for sides to infants' cots. As we stand watching the progress of the work of perforation, we cannot help admiring the perfect ease and smoothness with which the punches pass through the solid metal sheet, as a knife through a lump of butter.

Perforated zinc, of an infinite variety of patterns, is now very extensively employed for a multitude of useful and ornamental purposes—for meat-safes, larders, dairy windows, window blinds, ornamental covering to hot pipes, ventilation, filter bottoms, berry-sorters for the Ceylon trade, beds for troop-ships, &c., also to exclude mosquitoes and small reptiles in warm climates.

Leaving now the perforating room, we cross over to the right to inspect the warehouse for sheet-zinc in casks, and loose thick sheets. Here we see a great number of casks, weighing half a ton each, and containing zinc sheets of every gauge from No. 6 to No. 16. The thinnest of these are used for lining packing cases; the next numbers for perforated articles, frets, friezes, and a variety of zinc goods in general; whilst the highest numbers are more particularly employed for roofing, gutters, sash-bars, &c. &c. The whole of this large stock of zinc-sheets comes from the *Vieille Montagne* Works, near Liège, in Belgium, where the higher gauges, from 13 to 16, are manufactured express for

Messrs. Braby and Co., every sheet being stamped, "*Roofing Zinc; F. Braby and Co.*," to guard against imposition. In this warehouse are also stored numerous smaller casks, weighing one hundredweight each, and containing zinc nails for slaters, &c. The length of these nails varies from one to two inches; on the head of each of them are stamped the letters V. M. (*Vieille Montagne*). There is, besides, a considerable stock of zinc wires, of various gauges, here, and also of spelter cakes, weighing about thirty pounds each, which are used for the zincing of iron. Both the wire and the cakes are imported from the Belgian works.

At one end of this large store-room is the counting-house, which is constructed almost entirely of zinc. The walls are formed of corrugated zinc; the floor of plain zinc-sheets; the lights and windows are framed in various patterns of zinc sash-bars; the blinds are made of perforated sheets of various patterns, and the door panels ornamented with zinc mouldings. Ventilating frets of zinc complete the arrangement of this room, in which one feels almost disappointed to see desks and office stools made of the usual materials. We can detect no fire-place, yet find the temperature most genial; Mr. Braby informs us that the waste steam of the engine of the establishment is thus turned to useful account.

Descending now to the basement, we find a forge actively at work, attended by several stalwart sons of Vulcan. Near this we see a hot steam-press, of one ton weight's power, which is used for flattening sheets for door plates and name plates. There are also several draw benches for making tubes for bell-wires, speaking-pipes, &c., and also sash and casement bars, which is a very interesting operation. The slice of zinc-sheet which it is intended to form into a tube or bar is curved lengthways at one end, and in this condition passed through a steel hole or a die of the required gauge, a steel plug being inserted in a position to allow the metal to pass between it and the interior of the hole. The curved end is then laid hold of with a pair of huge nippers, attached to an endless chain, drawn by steam power. By this simple contrivance the flat sheet is in a few seconds converted into a tube, which requires only soldering along the seam to be ready for use. The slicing of the sheets to any required width is effected in the same compartment, by a cutting bench or machine, with circular shears, or cutting discs, revolving in opposite directions.

We now ascend to the first floor, an extensive compartment, where we find a moulding machine for making O. G. gutters; several machines for perforating German silver and cardboard, and tin-plates for lanterns; a planing machine, also three hand presses for filter bottoms, coffee percolators, wine, gruel, gravy, and jelly strainers. Here too is the engineering department; we find four lathes at work, and have the pleasure of seeing, in one of them, a roller in progress of being turned, intended for a new corrugating machine. A machine for making astragal mouldings, for strengthening pipes, is also at work here. The gutters, &c., for the Crystal Palace, both at Hyde Park and at Sydenham, were made in this room, which contains also all implements required for tool-making, the requisite punches and dies, and an extensive stock of various designs of metal perforators, in an iron safe, about seven feet high, by five feet six wide and deep. The contents of this safe constitute the most valuable part of the plant and stock of the establishment, many of the steel punches and dies being worth literally their weight in gold. The manufacture of friezes and frets belongs also to this department; formerly these articles were mostly made of lead, copper, or tin, but it has been found that zinc answers the purpose much better, as it is lighter, stronger, and cheaper than either of the other three metals, and admits of greater elegance of design. The proprietors of this establishment have an extensive assortment of zinc friezes and frets for lamps, verandahs; verandah valances, ridges for conservatories, ventilating frets for cabins of ships, and skirtings of rooms, and other purposes. They are at present executing a large order for ridges, friezes, &c., for the Horticultural Society, and there is also a contract with government for the supply of perforated zinc-sheets, for soldiers in troop-ships to sleep on, of which we saw samples, as also of bed-frames of galvanized iron, forming part of the same contract. These perforated sheets, with holes $\frac{9}{32}$ of an inch in diameter, are admirably calculated to insure proper ventilation, and preserve the health of the troops in long passages to hot countries.

The next upper floor, immediately above this, is the zinc-worker's shop, devoted chiefly to the manufacture of those multifarious disfigurements to our London roofs, which are employed for smoke-curers, and popularly called cowls, but are known technically as "*lobsters*," "*verticals*," "*malt-*

houses," "*Brightons*," &c. Here are made, also, ventilators, rain-pipes, casements, skylights, perforated zinc blinds, and a variety of other articles. We find, moreover, a circular-saw at work, cutting zinc cakes up into plates for galvanic batteries, each plate from an eighth to a quarter of an inch thick. At the extreme end of the shop a highly finished and polished ornamental clock case, in the Louis XV. style, attracts our attention. It is about nine feet high, made entirely of zinc, and every part of it hammered work. This elegant piece of workmanship appeared to great advantage at the Exhibition of 1862, affording a most convincing proof of the perfect adaptability of zinc for ornamental purposes.

The top story is used chiefly as a store-room for cisterns and for chimney cowls, smoke-curers, rain-water heads, and other articles in demand in the building trades. It contains, besides, an apparatus for making wire-netting, an article which, it appears, is also very extensively manufactured at this establishment.

Walking down stairs again to the ground floor, and then leaving the main factory building, we are now conducted by the courteous proprietor to a shed on the left, which contains a twenty-horse power oscillating steam-engine and boiler, with a Jukes' smoke-consuming furnace. This engine supplies all the power required for working the machinery of the establishment.

In the same part of the premises we find, also, a powerful machine for curving and corrugating galvanized iron, and another machine for corrugating zinc for roofing. There are two different patterns in use here, namely, the plain roll cap pattern, and the so-called *Italian*: the former of these represents an undulating succession of semi-circles, the latter a combination of the flat and the semi-circle. The rollers of both patterns are fitted to the same standard. A little further on, in the same compartment of the premises, we are shown the plain iron rollers through which the iron sheets are passed after being galvanized or zinced: also a machine for punching holes for rivets through the corrugated zinc sheets.

Adjoining this shed there is a ten-roomed warehouse for storing galvanized iron goods, of which Messrs. Braby and Co. keep a very extensive assortment, consisting of buckets, pails, wash-hand basins, bowls, cans, watering-pots, coal-

scuttles, scoops, turnip skeps, and a variety of other articles of the kind. These goods are usually first made up in the black iron, and then coated with zinc. One of the rooms of this warehouse contains a selection of extremely comfortable wrought-iron folding garden stools and chairs, with spiral galvanized wire seats and backs.

On the right-hand side of the yard there are stables and other offices and out-buildings of the kind. At the end of the yard there is a large packing warehouse, covered with Italian roofing. The Italian pattern of corrugated zinc roofing would appear to be vastly superior to the common plain roll cap system formerly in use, both as regards appearance and strength and durability. It is said to provide amply for the expansion and contraction of the metal, and is certainly more economical, as it requires no boarding, king-post, struts, or tye-beam, but simply wood rolls under the flutes: and the Italian system of corrugation reduces the plates only from 3 feet in width to 2 feet 6 inches.

The objection occasionally made against the employment of zinc for roofing, that the metal will not stand hard wear and tear, is not well founded, as it applies only to roofs made of sheets of the lower gauges of thickness, such as Nos. 9, 10, or 11; Messrs. Braby and Co. make it a rule never to use sheets for roofing of a lower gauge than No. 13, and it is generally found that this description answers every purpose desired.

We are now, finally, invited by our courteous conductor to visit the galvanizing room. There we see numerous wood and slate tanks, and a large wrought-iron bath. Mr. Braby tells us that the iron sheets and other articles which it is intended to *galvanize*,* are first immersed for several hours in a bath of diluted hydrochloric or sulphuric acid, or a mixture of both. They are then thrown into cold water, and taken out one at the time, to be scrubbed and scoured to detach the scales and thoroughly clean the surface. After this they are thrown for a few minutes into a bath of pure acid, then dried in a hot closet, and finally dipped in the large wrought-iron bath, which contains about 20 tons of molten zinc, covered with a thick layer of sal ammoniac; from this they are slowly raised, to allow the superfluous

* The term *galvanizing* as applied to the coating of iron with zinc in the manner here indicated, is clearly a misnomer; still, as it is so very generally used, we have thought it best to retain it here.

zinc to drain off, and the sheets are then passed through plain iron rollers, and afterwards bundled into 1 cwts., ready for the market. Other galvanised articles are simply thrown into cold water and then wiped dry. The fire all round the galvanizing bath is never permitted to go out.

Before taking our final leave of the establishment of which we have endeavoured to give our readers, however so slight, rapid, and imperfect a sketch, it is our most pleasing duty to express our thanks to Mr. F. Braby, and to every one employed in his establishment, for the extreme courtesy with which we were received and shown over every part of the works. From the clerk in the office to the labourer in the yard, from the foreman of the engineering department to the lad who, at the time of our visit, was working small percolator bottoms at a hand press, we found every body most obliging, and anxious to give us every desirable information.

BRASS FOUNDING.

For the subject of this article on manufactures in metals, we have selected *brass*, as this appears the most natural seque to the subject of the preceding article, *zinc*, which, as we have had occasion to remark, forms one of the principal constituents of that most important alloy.

The brass of the ancients, it would appear from the results of an extensive series of analyses of ancient coins, &c., made by Mr. J. Arthur Phillips, up to the Christian era contained no zinc, but consisted chiefly of a mixture of copper and tin, and ought therefore more properly to be classed with bronze or bell-metal. About the Christian era zinc would appear to have been first employed for the purpose of forming an alloy with copper.

Copper is one of the most useful and valuable metals. It was known to the ancients, and derived its name from the Island of Cyprus, where it was first wrought by the Greeks. It has a peculiar reddish-brown colour, and a faint but nauseous taste; when rubbed between the fingers, it evolves a disagreeable odour, somewhat similar to its taste. It is

about nine times heavier than water (cast copper, 8·78; rolled or hammered, 8·96). It is very ductile, and still more highly malleable, and an excellent conductor of heat and electricity. It is not well adapted for casting, as it does not take a sharp impression; it is partly for this reason that our copper coins are stamped, instead of being cast. It fuses at about 1996—2000° Fahrenheit; at a higher temperature, it passes off in fumes, which burn in the air with a bluish-green flame. In dry air it does not oxidize at ordinary temperatures, but in air not perfectly dry it slowly tarnishes, a slight film of suboxide forming on the surface; in damp air it becomes covered with a strongly adherent green coat, consisting chiefly of carbonate. Heated to redness in the air, it is rapidly converted into black scales of oxide. The tenacity of copper is considerably greater than that of gold, silver, and platinum, though still inferior to that of iron. Before the discovery of malleable iron, copper was the chief material used in the manufacture of domestic utensils and implements of war; though now in a great measure superseded by iron, it is extensively employed for many important purposes, as, *e.g.*, sheathing and bolts for ships; brewing, distilling, and culinary vessels; fire-boxes for locomotive engines; boilers for marine engines; plates for engravers; &c.

Besides *native copper*, which is found abundantly in Siberia, Hungary, Gallicia, Sweden, Cornwall, &c., and more abundantly still in the mines of Lake Superior in North America, where masses exceeding 150 tons in weight have been found, there are about twelve different species of copper ores, of which the sulphide and copper pyrites are the most important. These ores abound in Siberia, Saxony, Sweden, Cornwall, Devon, Wales, Westmoreland, Cumberland, &c.

The total quantity of copper ore raised in the United Kingdom of Great Britain and Ireland amounts now to about 350,000 tons per annum, and the fine copper obtained from this to about 25,000 tons, of an estimated value of from £2,500,000. to £3,000,000.

Copper forms an important series of alloys with other metals, more especially with gold and silver, for coin, plate, &c.; and with zinc, tin, and lead. The alloys of copper with the latter three metals are comprised under the general name of *brass;* but in the more common acceptation, the use of

this term is restricted to the alloy of copper with about one half its weight of zinc, which is called by engineers *yellow brass*. With tin, copper forms gun-metal, bell-metal, bronze, speculum metal, hard brass, &c.; with lead, pot-metal or cock-metal; with zinc and nickel, German silver, of which we shall have occasion to speak hereafter. Brass, made of the proper proportions of copper and zinc, is actually more ductile and less easily oxidized than copper, contrary to what might be inferred from the opposite nature of zinc, for the physical and chemical character of which latter metal we refer to the article preceding this.

The principal places where brass is manufactured on a large scale, in England, are Bristol and Birmingham, brass-founding being, in fact, one of the leading trades of the latter city, which we have accordingly selected for our visit. We therefore now invite the reader to accompany us to the

BRASS-FOUNDRY AND TUBE WORKS OF WILLIAM TONKS AND SONS, MOSELEY STREET, BIRMINGHAM,

Manufacturers of every description of brass work used by builders, shipwrights, cabinet and piano-forte makers, &c.; one of the oldest firms in this line of business, having been established as early as the year 1794.

We are received most courteously by Mr. Edmund Tonks, one of the partners, who kindly offers to conduct us over the works, and act as our Cicerone.

The buildings, which have only recently been erected, form a square covering 2000 square yards of ground. One side of the square, facing Moseley Street, is occupied principally by the warehousing department. Here we have, on the ground floor, the packing room, which is furnished with every convenience required for the purposes for which it is intended; a hoist, capable of lifting half a ton to the third floor, serves to pass goods, &c., from one floor to another, up and down, through traps in the ceilings. The metal store-room contains large quantities of ingots of copper, of two different qualities, viz., ordinary and "best selected;" and of spelter, principally foreign.

All the brass used for casting is made on the premises. There are two qualities used, viz.:

First quality, for *fine castings*, where the moulded surface is preserved in the finished article. This consists of three parts of "best selected" copper and two of spelter, melted into ingots, with a proportion of best scrap brass and a little tin.

Second quality, for ordinary work. This consists of two parts of ordinary copper and one of spelter, melted into ingots, with a proportion of scrap brass and brass filings. Before the latter are used, the iron filings are separated from them by means of an ingenious machine, the main part of which consists of a revolving endless chain frame with eighty magnets attached to it, and turned by steam power.

Both qualities of brass can stand the process of "*hard* soldering," that is, soldering with brass solder, without melting. No lower quality of brass is used in this foundry. There is also a large stock of sheets of rolled brass, used for making tubes and for stamped and pressed work, and of brass wire. Both these articles are procured from mills, whose exclusive business it is to roll and draw for the trade.

We now come to the casting pattern room, which contains a bewildering number of metal patterns of every description, from the plainest to the most highly ornamented. To give a notion of the number and infinite variety of these patterns, it need simply be stated that there are more than 10,000 regular trade articles made by the firm, besides thousands of articles made to special order, and patterns are kept here of all of them. Though individually small, they collectively weigh more than three and a half tons! Every pattern is numbered, and the whole collection arranged in a multitude of drawers, each of them numbered and divided into compartments. A reference-book is kept, by means of which even a stranger may find any required pattern in a few minutes.

From the pattern room we proceed to the "Rough Warehouse," an immense room, ninety feet long, with a light gallery running round it. The work is brought in here from the casters, and given out to the finishers. We are shown an infinite variety of rough castings kept in stock here, in numbered boxes.

We now come to the smelting or metal mixing shop, where the pig brass is made. Here we find three air furnaces, each

melting about 120 lbs. of metal at a time. Before zinc was known in a metallic form, brass was manufactured by cementing granulated copper, called *beanshot*, or copper chippings, with calcined calamine (native carbonate of zinc) and charcoal, in a crucible, and exposing the mixture to a bright-red heat. This method is even now still occasionally followed, but here, as indeed now in most foundries, direct fusion of the two metals is resorted to. The crucibles, or melting pots, used here in the metal mixing shop, as well as in the casting shops, are procured from the Patent Plumbago Crucible Company's Works, at Battersea. These Plumbago crucibles, though twelve times dearer than the common Stourbridge clay melting pots, to which most founders still cling with the characteristic obstinacy of the British manufacturer, are yet found to be much more economical. Mr. Edmund Tonks informs us that they require only one half the ordinary amount of fuel, and will run a considerable number of pourings; there is also a great saving of time, and consequently diminished oxidation of the zinc; moreover they are not liable to crack, and will stand any change of temperature, however sudden; they can consequently be worked with perfect safety. So convinced are Messrs. Tonks of the superiority of these Plumbago crucibles that they use them now *exclusively*. There are several casting shops, some for *fine castings*, others for ordinary work, all of them in active operation, and thus affording us an opportunity of witnessing the several processes. The principal materials for making foundry moulds for brass castings are fine sand and loam, mixed in various proportions, according to the nature of the work. New sand is used for fine castings, old sand for ordinary work. The requisite external support is given by a couple of shallow rectangular iron frames, without tops or bottoms, called *flasks*, or casting boxes.

The two halves constituting a casting box carry ears corresponding exactly with one another, one set pierced with holes, the other furnished with points entering truly into these holes, and which may be made fast in them by cross-pins, or wedges. One of the flasks is laid face downward on a board longer and wider than it, and is then rammed full of moulding sand; the surface is struck off level with a straight metal bar or scraper; a little loose sand is sprinkled upon it, and another board of proper size placed over it, and

rubbed down close. The two boards and the flask contained between them are turned over, and the top board is taken off; the clean surface of moist sand now exposed is dusted over with perfectly dry fine parting sand, or very fine red brickdust. The patterns or models are now properly arranged on the surface of the same, the cylindrical or thick parts being partly sunk in the latter, and care being also taken to leave sufficient space between the several patterns to prevent one part breaking into the other, and also passages, or *ingates*, by which to pour in the metal, and allow the air to escape. The patterns are arranged on both sides a central passage, or runner, technically called a *ridge*, from which again small lateral passages are made, leading into every section of the mould. The general surface is then properly arranged with the aid of small trowels, and a little fine parting sand or brickdust is shaken over it. When this has been accomplished, the upper part of the flask is fitted to the lower by the pins, and then also rammed full of mould-sand. The fine dry parting sand or brickdust serves to prevent the two halves sticking together. A board is now placed on the top of the upper half, and struck smartly in different places with a mallet, after which the upper half and its board are lifted up very gently and quite level, and then turned over, so that the upper half rests inverted on its board. The models are now removed, and channels scooped out from the cavities left by them, to the hollows, or pouring holes (*ingates*) at the end of the flask. Solid cores of sand are adjusted in the proper places when the article is required to be cast hollow (brass-cocks, for instance), and also iron rails intended to have brass heads cast on them, or such other articles of iron as are required to be solidly united with the brass. The faces of both halves are now finally dusted with waste flour or meal dust; the two halves are then replaced upon each other, and the box is fixed together by screw clamps. The moulds for *fine castings* (articles with ornamented surfaces, as screens, sconces, bell-levers, &c.) are faced with various fine substances, such as charcoal, loamstone, rottenstone, &c., that they may retain a sharp impression; after which they are most carefully dried. For ordinary work, it is generally considered better that the sand should retain a little moisture, though great care must be taken in this respect, to guard against the danger of explosion.

The moulds, fixed together by screw clamps, as just now stated, are ready for filling. Great care is required in melting the brass that the temperature be not too high, as the zinc oxidizes with great rapidity, burning with a bright bluish-white lambent flame, and pouring forth volumes of dense white fumes, which sublime in the form of a flocculent white substance (oxide of zinc), familiarly known as "philosopher's wool." Some loss from this cause is always quite unavoidable; in casting small articles, where the *ridges*, that is, the metal which forms the channels, have to be successively remelted, averages, with a careful caster, 7 lbs. in the cwt.

When the caster judges the melted metal to be of the proper temperature for pouring, he lifts the crucible, or pot, out with a long pair of crucible tongs, and carries it to the skimming place, where the loose dross is skimmed off with an iron rod. He then proceeds to fill the mould, which operation is attended with a rushing or hissing sound from the flow of the metal and the escape of the air, and generally also by small but harmless explosions of the gases which escape through the seams of the mould.

Before the castings are cold the moulds are opened, the ingates or ridges sawn off, and the ragged edges, where the metal has entered the seams of the mould, filed away. The cast articles are then freed from adhering sand by shaking in a *rumble*, or revolving barrel, moved by steam power. After this they are taken to the rough warehouse, where they are given out to the finishers.

We now proceed to the annealing shop, which contains a number of annealing stoves, where the brass work, in the course of the several finishing operations, is repeatedly heated to redness, and then allowed to cool again. Ornamental works,—more especially such as house furniture, lamp and gas fittings, &c., no matter whether stamped or cast, after having been fitted together by hard soldering, are annealed here, to remove any grease or dirt that may have gathered on them in the processes of fitting, and to prepare the articles for the subsequent operations of pickling, dipping, &c. Here are also tempered a variety of steel springs, used by bell-hangers, piano-forte makers, &c.

The next place we visit is the engine-room and the engineers' fitting shop. Here we find a high-pressure engine of fourteen-horse power at work, and active prepa-

rations going on for putting down a new Cornish boiler of twenty-horse power, as the extension of the application of steam to every department of the works demands a very considerable increase of power. In this factory steam is, in fact, made to do all the work of which it appears capable, the shafting being carried into every workshop in the building; great care has been taken in this to erect the shafting everywhere out of the reach of the workmen, and to fence all dangerous bands, so as to render accidents all but impossible, except from gross or wilful carelessness. The engine works also a fan revolving, almost noiselessly, with the amazing velocity of 6,000 revolutions per minute, and supplying the necessary blast to the forges in the smiths' shops and in other departments, and also to the gas-soldering apparatus in nearly every room, the air being carried, by means of cast-iron pipes branching in different directions, to the most distant parts of the premises. Bellows are thus altogether dispensed with in the establishment, and most of the soldering is done by the air-gas pipe, which, of course, immensely facilitates the operation.

All the tools used in the establishment are made here, in the engineers' fitting room, which contains various machines for working in iron; among these may be mentioned a self-acting compound slide-rest on a screw-cutting lathe, with wheel-cutting and slotting apparatus, and a combined drilling and surfacing machine of a novel construction.

From the engineers' fitting shop, we proceed to the tube shop. The brass sheets procured from the rolling mills are here cut, by revolving shears, into strips of any required width; the metal is then partially curved in its length by means of a pair of rolls, and after this transferred to the draw-bench, and there treated as described in the preceding article, for the manufacture of zinc-tubes. The tube shop in Messrs. Tonks' establishment is fitted with two powerful cast-iron draw-benches, with endless revolving chain; also with circular shears, rolls, and every other requisite apparatus; adjoining it, on the basement, there are stoves where the tubes are soldered. Here we are also shown a very large circular gas-meter, a so-called "*station meter*," of sufficient capacity to supply the immense quantity of gas required in the establishment for soldering and a variety of other purposes.

From the tube shop we ascend to one of the principal workshops, which is eighty feet long by twenty-five feet wide. Down the centre are arranged a double row of lathes, driven by steam-power, all on planed cast-iron beds, and fitted with fast and slow motion and reversing apparatus. There are numerous other workshops of the same kind, fitted altogether with eighty steam-power lathes and 197 vices. In this department are conducted the different processes of finishing, by filing, turning, &c., the various articles made by the firm.

The surface of brass-work is finished by the following processes:—

"*Sanding*," which consists simply in rubbing with fine emery the surface of the article after it has been filed smooth.

"*Dipping*."—After the surface has been carefully filed, and the article annealed, it is plunged into a bath of pure nitrous acid, commonly known as "dipping aquafortis," contained in a glass or earthenware vessel. There must be sufficient acid in the vessel to cover the work entirely as far as the application of the acid is intended to extend. If the work does not require to be wholly immersed, it is handled with the fingers; but if the entire surface is to be covered, brass pliers must be used, as the use of wood or iron instruments would spoil the bath. The greatest care is taken to leave the immersed article only for an instant in the bath, as the acid acts most energetically on the metal; accordingly, the work is quickly removed out of the bath immediately after its immersion, then plunged successively, with great rapidity, into several vessels containing cold water, and into one with hot water, and is well rinsed in the water to remove every trace of the acid.

"*Burnishing*," i. e., rubbing the surface after it has been carefully filed, and the article has been annealed and dipped, with a bright steel tool or "burnisher."

"*Polishing*."—This may be done in various ways. Here the practice is to submit the article prepared by the file to the action of wheels revolving at a high speed, charged first with very fine sand, afterwards with Sheffield lime.

"*Bronzing*."—There are a great variety of surface bronzes used; the bronze metal proper, however, is very rarely employed here, the desired effect being generally produced by chemical or galvanic agency. Vinegar is sometimes used

as the bronzing liquid, or dilute aquafortis, or a strong solution of sal ammoniac in dilute nitrous acid, or a solution of sal ammoniac in vinegar, in the proportion of one ounce and a half of the salt to a pint of vinegar. The so-called "chemical bronze," which consists of a solution of platinum in nitro-hydrochloric acid, or aqua regia, produces the desired effect in a few minutes, but is rather expensive. Whatever agent may be employed, it is indispensable that the article to be bronzed should be perfectly clean, to allow the acid to act uniformly on the surface.

"*Lackering.*"—This is the final operation. The lacker used here is made on the premises; it consists of a solution of seed lac, or shell lac, in methylated spirit, coloured with various substances, such as turmeric, saffron, cape aloes, or gamboge, for yellow tints; annotto or dragon's blood for red tints. In the lackering-room, a number of women are seated round large cast-iron plates, heated by stoves underneath, but completely out of reach of the dust or smoke from the fire; the work being laid on these plates, gets heated to the proper degree for the lackering process: the lacker is applied with the brush in successive coats, the strokes of the brush being taken in parallel lines from side to side.

From the lackering room we proceed to the stamping shop, where we find three stamps at work, stamping a great variety of articles out of sheet brass; the press shop, which is heated by steam, and where the press work is done principally by women; and the carpenters' shop, which contains a steam saw, and where all the carpentering work of the establishment is done.

As our readers will have gathered already, from the number of workshops, machines, lathes, &c., mentioned in the preceding brief sketch, Messrs. W. Tonks and Sons employ a great many hands. We learn from Mr. Edmund Tonks that the majority of the workmen have actually been reared in the employ of the firm, and that many of the leading brass trades in Birmingham were originated by workmen from this manufactory.

A sick fund and benefit society, which the hands employed by the firm have established among themselves, Mr. Edmund Tonks informs us, is in a flourishing condition, and affords a very powerful argument in favour of the establishment of provident associations of this kind.

The workmen have also formed, with the aid of their liberal employers, a circulating library of their own.

After a brief visit to the finished work rooms, which are very extensive, the main room, measuring ninety feet by twenty-two, we take our leave of the establishment, much pleased with all we have seen, and most favorably impressed with the thoroughly practical arrangements witnessed in every department of the business.

GERMAN SILVER.

COPPER, zinc, and nickel, combined in different proportions, form an important series of alloys, known under the names of *German silver*, *Nickel silver*, *Albata*, *Argentane*, *Argentine plate*, *British plate*, *Electrum*, *Pakfong*, *Tutenag*, *Virginian plate*, *&c.*

As a general rule, these alloys are the harder and whiter the more nickel they contain. Most of them are employed as substitutes for plate, the remainder for harness furniture, drawing and mathematical instruments, spectacle frames, &c.

Argentane, or common German silver, generally consists of eight parts of copper, three of zinc, and two of nickel; it has often a yellow tinge, and is, therefore, now only used for inferior articles. The better sorts of German silver consist of four parts of copper, two of zinc, and two of nickel, or eight of copper, six of nickel, and five of zinc; a small proportion of iron (about two per cent.) is occasionally added, which, it would appear, increases the whiteness of the alloy, but tends, at the same time, to render it harder and more brittle, and accordingly a little less easily workable, though it remains still perfectly malleable at common temperatures, and even at a moderate red heat; at a red-white heat it has a tendency to become over-brittle and unmanageable.

Electrum consists of eight parts of copper to four of nickel and three of zinc; Argentine plate, eight of copper, three of zinc, and three of nickel. These two may be said, at the present time, to be the most frequently employed in

the manufacture of the best kinds of imitation silver articles. However, quite recently, Messrs. John Yates and Sons, of Birmingham, have invented a new composition, which would appear to come nearer still to silver in whiteness, polish, sonorousness, and resistance to oxidation by vegetable acids. This new compound, to which the inventors have given the name of *Virginian plate*, or *Virginian silver*, seems, indeed, in every respect admirably adapted to serve as an efficient substitute for the real article. The proportions in which the copper, zinc, and nickel are combined in it, are, of course, kept secret by the firm.

The physical and chemical characters of zinc and copper having been described already in the two preceding articles, it remains here only to say a few words about those of the third component element of the alloy, viz., nickel.

Nickel has a fine silvery white colour and lustre; it is hard, but malleable, both hot and cold; it may be rolled into sheets 0·005 of an inch thick; when quite free from arsenic it is also ductile, but to a more limited extent, as it cannot be drawn into wire thinner than about 0·05 of an inch. It acts upon the magnetic needle, and may itself be made magnetic; but its magnetism is inferior to that of iron, and is completely lost at a dull-red heat (about 630° Fahr.) The specific gravity of nickel varies between 8·28 and 8·40 when fused, and, after hammering, between 8·70 to 9·00. At common temperatures it does not tarnish in the air, but upon exposure to heat, with free access of air, it acquires various tints like steel; when exposed to a red heat a film of gray oxide forms on the surface of the metal. It requires a very high degree of heat for fusion. It is scarcely used in the arts in the simple state, though attempts have been made, it would appear with some success, to strike coins in it. The ores of this metal were formerly greatly neglected: and it is, in fact, only since the manufacture of German silver has become an object of commercial importance that proper processes for the extraction of the metal from its ores, more particularly from copper nickel, or *speiss*, have been devised. A few mines of copper nickel, sulphide of nickel and copper, and arsenate of nickel, are at present in working in various parts of Cornwall, but most of the metal used in English manufactories of German silver, &c., is imported from Sweden, Norway, Germany, the Netherlands, Spain, Sardinia, the United States, &c., either as ore or in the metallic state.

The metal is usually sent into the market granulated, the size of the pieces hardly ever exceeding that of a small bean.

Having thus briefly described the material, we will now proceed to consider the various operations and processes by which it is converted into spoons, forks, cruet frames, tea sets, candlesticks, and a variety of other articles for use or ornament. We have, on this occasion, selected for our visit the

ELECTRUM, ALBATA, AND VIRGINIAN PLATE MANUFACTORY, AND ELECTRO-PLATING WORKS OF JOHN YATES AND SONS, PRITCHETT STREET AND COLESHILL STREET, BIRMINGHAM.

We were most cordially received by Mr. Edwin Yates, one of the partners, and conducted by him over the works in both localities. Mixing and melting the metals is the first operation. The foreman gives out to the casters the proper quantities of the copper, zinc, and nickel; a proportion of scrap metal is added, and the whole then melted in furnaces, in pots of Stourbridge fire-clay, which, however, do not answer the purpose quite so well as might be desirable, and will, it is to be hoped, speedily be superseded in this as well as in other establishments by Patent Plumbago melting pots. There are four pairs of furnaces in actual use in this establishment; when the metallic mixture is in proper flow the crucible is grasped between the jaws of a pair of tongs, lifted out of the furnace, and, after stirring and skimming, cast into ingots, or *strips*, weighing from eighteen pounds upwards. The operation is technically called "strip-casting."

The strips are heated to bright redness in annealing furnaces, then allowed to cool, and when cold passed through iron rollers, worked by steam. The action of the rollers reduces the strips to the gauge required, which varies between Nos. 3 and 20, Birmingham wire gauge (0·259 and 0·035 of an inch); as a general rule, however—at least in this establishment—the strongest metal used is No. 7=0·180

of an inch thick. When this part of the process is completed the strips are re-annealed, then clipt by a clipping machine, and, according to the nature of the articles to be manufactured, cut out in disks, or other shapes, or slit up into strips of greater or less width, for spoons and forks.

The strips intended to be made into spoons or forks are again annealed, and then once more submitted to the action of the rollers, but simply as regards the ends, to the extent of about one third at each end, leaving the central part untouched. This operation has for its object to leave the central part thicker and stronger than the ends, and to widen the latter. The strips so prepared are now taken to the press-shop, where the exact shape of the blank is cut out by fly-presses, or *cutting* presses, worked by steam. A heavy revolving fly is attached to the screw of the press; when the machine is set to work this fly is put in rapid motion, which is suddenly arrested by the dies or cutters coming in contact with the sheet of metal submitted to their action; the dies or cutters being screwed into a square bar attached to the screw, and in an exact line with it, the entire momentum of the fly, thus directed by the agency of the screw, is brought to bear upon the metal; the bed or bottom die, which, of course, is strictly parallel with the top die, rests on the base of the press, being retained in position by four screws, which allow of its accurate adjustment. A great variety of cutting-out tools are kept for every shape of spoons, forks, &c. The prongs of the forks are pierced by a similar process. The cut-out flat spoon or fork, after being once more annealed, is then submitted to the action of the stamping machine, to receive the impression of the pattern. In Messrs. Yates' factory this is still effected by several distinct operations with different dies—that is to say, the impression is given, in the first place, to the handles, the bowls or prongs being formed afterwards. The advantage of this over Hayne's new process, by which the article is brought up perfect at one blow, would appear to consist principally in this, that the separate stamping of the handle tends to thicken and strengthen the central part, or *bosom*, of the spoon or fork. After stamping the handle, the spoon or fork is taken to the filing shop, re-annealed afterwards, and then brought to the *bowler's* shop, which contains the stamps for the bowling of spoons and the bending of forks, also for rounding the prongs of the latter. The essential parts of a stamping

machine are, first, a large massy stone; second, an anvil resting on this stone; third, a steel boss or die, called the bed or bottom die, which is screwed in the anvil by four screws; fourth, a heavy block of metal, termed *hammer*, or *drop*, on the lower surface of which is fastened, fifth, another steel die, called the top or *counter-die*, corresponding, of course, with the lower die; sixth, two upright square prisms, of proper height, set diagonally, with the angles opposed to each other; the hammer having nicely fitted angular grooves or recesses in its sides, slides truly between these prisms. A rope is attached to the hammer; which passes over a pulley; by means of this rope the hammer is raised to the proper elevation, the article which it is intended to submit to the action of the stamp is placed upon the lower die, and the hammer then let fall; one workman attends to the raising and dropping of the hammer, another puts the spoons, forks &c., under it. Every pattern of spoons, forks, &c., of which there are a great variety, *e. g.*, Coburg, King's, Lily, &c., requires, of course, different top and bottom dies.

The article is now taken back to the filing shop, where it receives its finish by filing; it is then ready either to be sent to the mill for polishing and colouring, or to the electro-plating department. Stamping is also resorted to for the production of a variety of other articles, more especially of simple form, such as bottoms of candlesticks, covers, and lids of teapots, cups, and other vessels; the feet of tea-urns, the branches of candlesticks, and the handles and spouts of tea and coffee-pots, &c., are also formed under the stamp in two semi-cylindrical halves, which are subsequently joined together. Certain articles of a more complicated form are raised as far as practicable by stamping, and afterwards finished on a chuck in the lathe, by means of a burnisher; this operation is called *spinning* or *burnishing to form*. Others, such as the bodies of tea-pots, coffee-pots, &c., vases, and other vessels measuring less in diameter at the top and bottom than in the middle, are *raised by the hammer*, that is to say, by the application of circles of blows proceeding in a certain order and direction, according to the shape required. The principal conditions in raising works by the hammer are, 1, to select the metal disk to be operated upon of such size and thickness as will exactly suffice to produce the article, leaving no excess of metal to be removed, nor deficiency to be supplied; 2, to regulate the blows of

the hammer as to direction and intensity, in a way to ensure uniform thickness throughout in the finished article. As the hammering of works of this kind necessarily demands a constant change of position, the workman simply uses his unassisted hand in turning the article in progress of manufacture about the anvil. The blows applied are of two different kinds, viz., blows given with the hammer directly opposed to the face of the anvil, which accordingly tend to thin the metal by its sudden compression between two hard surfaces; and blows given on the plate resting against the edge of the anvil, which accordingly tend to bend it to the form of the supporting edge, and to thicken it. The former are technically called *solid* or *opposed* blows, the latter *hollow* or *unopposed* blows.

In the several operations connected with raising works by hammer, a variety of tools are required, too numerous to mention for the limited space at our disposal here. When the general form of the article is finished, the various ornamental details, such as escutcheons, concave and convex flutes, &c., are added by the application of so-called *swage* and other tools. If the shape of the article does not permit the employment of *swage* or *creasing* tools, a so-called *snarling* iron is employed for raising the projecting parts. This tool consists of an iron bar turned up at both ends, at a somewhat obtuse angle, and of more than sufficient length to reach any part of the interior of the vessel; one end of this iron is firmly secured between the jaws of a tail-vice, the other end, turned up, has an angular, cylindrical, or globular shape given to it, according to the nature of the fluting or ornamentation required. The flutes, escutcheons, or other ornamental details, are sketched with the compasses upon the plain surface of the vessel; the free end of the snarling iron is introduced into the latter, which is then laid firmly hold of with both hands, the part to be raised or *set-out* always being placed exactly over the end of the snarling iron. An assistant now strikes the free projecting part of the iron with the hammer, the reaction giving a blow within the vessel, which throws out the metal in the form of the end of the tool. After the flutes or other ornaments have been snarled-up in this manner, the vessel is filled with melted pitch, or with a mixture of pitch and resin, or a composition of pitch and brick-dust, and the ornamental parts are then corrected with punches or *chasing tools* of the

counterpart forms, by which certain portions of the metal are driven inward, thus making those around rise up from the displacement of the pitch or other composition inside. The lower surface of the vessel is supported upon a sand-bag, to protect it from injury; the adhesive and yielding action of the pitch enables the workman to make use of both hands, the left to hold the punch or chasing tool, the right to wield the small hammer used in striking it.

Feet, handles, spouts, &c., are occasionally, in some establishments, soft-soldered on the bodies of the articles; but Messrs. Yates always hard-solder them, as this makes the work so much better and more solid; the soldering is done in the gas flame, which is made to play on all parts of the vessel, to prevent injury to the metal from unequal distribution of heat.

Beads and mouldings are also generally formed upon the edges of vessels, &c., not merely for the purpose of ornamenting them, but also to give additional strength and stiffness. Such beads and mouldings are now mostly produced by the action of rollers, that is to say, two wheels, a lower one with the beading, and an upper one with the groove corresponding; the wheels are placed upon axes furnished with toothed pinions in the middle, the lower being turned by a handle gives motion to the upper, and the slip of metal passed through between them is thus made to assume the same shape.

The finished article is now ready for the polishing and colouring mill, or for the electro-plating bath.

The latter is an apparatus consisting of two distinct parts, viz., the voltaic apparatus, from which the electric current is obtained, and the vat in which the silvering or gilding is brought about. According to the quantity of electricity to be generated, and the intensity of the current required, the battery consists of one, two, three, or more cells (large earthenware jars), containing dilute sulphuric acid and a zinc plate, with a plate of copper on each side, so as to turn both sides of the zinc plate to useful account; the zinc plate is coated with mercury to protect it from over-rapid corrosion. The *vats*, or plating vessels, are generally from four to seven feet long, by three feet broad, and three feet deep; the larger size holding from 200 to 250 gallons of liquid; solution of cyanide of potassium in water is the liquid used. In large establishments, such as Messrs. Yates', the cyanide of

potassium, is made on the premises, by fusing the prussiate of potash (eight parts) with salt of tartar (three parts), in an iron pot. The fused mass is gradually transferred, with a ladle, to a large shallow brass basin standing in another basin containing a little water, to accelerate the cooling of the fused cyanide. Extreme caution must be observed in this to guard against the least drop of water finding its way into the brass basin, as the contact of the hot cyanide with however so small a quantity of water is sure to give rise to dangerous explosions. Some years ago an explosion of this kind took place on Messrs. Yates's premises, in connection with which Mr. Yates told us an anecdote so strongly illustrative of the coolness and unshaken nerve of the British workman in a position of difficulty and danger, that we cannot forbear giving it to our readers. The man whose business it was at that time to attend to the making of the cyanide of potassium, happened to delight in a huge pair of whiskers, which, in those beardless days, it would appear, exposed him to a good deal of chaffing on the part of his fellow-workmen, and repeated requests to "shave." One morning, when these little annoyances had been carried rather further than usual, he jokingly promised to shave off the objectionable hair on the morrow. A few hours after, some act of carelessness, either on his part or on that of his assistant, led to an explosion, scattering the hot cyanide in every direction, and throwing a portion of the boiling mass right into his face, which it burnt in the most frightful manner. Upon his fellow-workmen coming to his assistance from all parts of the premises, he quietly turned to them, and, laying hold of his whiskers with both hands, and pulling them off along with the scalded skin of his cheeks, coolly exclaimed, "Well, you see, I shall not want to shave, after all, to-morrow!"

Silver plates are placed at intervals in the vats; these plates, which form the positive pole in the solution, correspond in surface to the articles to be coated, and face them on both sides. Two brass rods are laid over the vat lengthways, one on each side, about six inches from the border; these serve to support the copper wires by which the articles to be coated are suspended; the zinc pole of the battery is connected with them in the usual way, the copper pole being connected with the metallic sheets in the solution by means of a copper slip. As soon as the silver plates and the

articles to be coated are both immersed in the solution, the voltaic circuit is completed.

The articles to be plated are first boiled in solution of potass in water, to free them from grease; they are then quickly dipped in red nitrous acid, to remove any oxide that may have formed on the surface, and after this twice washed in different tanks of water, to remove every trace of the acid. After carefully weighing them, they are suspended from a number of copper wires, and dipped into solution of quicksilver in cyanide of potassium; then again twice washed in different tanks of water, before immersing them in the silvering solution; one of these wires has two projecting bits of copper attached to it, to distinguish it from the others, this is called the test rod: when the operator has reason to believe that nearly a sufficient amount of silver has been deposited on the article, he removes this rod from the solution, and weighs the article, to ascertain whether the process is completed, or how much longer it will take to complete it. Any thickness of silver may of course be given to an article by continuing the operation sufficiently long, but from three to six hours generally suffice to give a proper coating of silver; 1½ ounce of silver to the square foot of surface is considered to form an excellent plate. The silver-plated articles are well brushed with brushes of very fine brass wire, attached to a lathe, and cleaned with fine Calais sand, to prepare them for the burnishing or colouring shop. The process of gilding is nearly the same as that of silvering, plates of gold being of course suspended in the cyanide of potassium solution, instead of silver plates. The old zinc plates are broken up, to get back the quicksilver with which they were coated. The copper wires also are taken to the so-called waste-shop, to strip off and recover the silver from them. All the sweepings of the various work-rooms, &c., are also taken to the waste shop, where the metal contained in them is carefully washed out. The last finish is given to the article by the operations of polishing, colouring, and burnishing.

Articles of albata on Virginian plate, which it is not intended to electro-plate, are polished on buff wheels with Trent sand, which is remarkably fine and sharp, and admirably adapted for the purpose. Sheffield lime, sifted as fine as possible in a shaking machine worked by steam, is used for the finishing or colouring.

Electro-plated articles are first polished on revolving brushes on lathes, with rottenstone, then by hand with a buff stick (a strip of leather glued on wood), rouge being generally used in this second operation instead of rottenstone. The colouring finish is finally given with the naked hand, the finest rouge being used for the purpose. This last operation is performed by women, who, from the greater softness and delicacy of the skin, greatly excel men in the art of polishing.

Tea-pots, cruet-frames, candlesticks, and articles with fluted, chased, and ornamented surfaces, are also *burnished*. The burnisher is a piece of very highly polished hardened steel (sometimes also of bloodstone, flint, or agate), fitted up with a handle, which, when judiciously applied to the smooth surfaces of metals, imparts to them, by friction, a very high polish. The articles submitted to the action of the burnisher must previously be carefully smoothed, and all file-marks or scratches removed from the surface. The burnishing also is done by women and girls, who generally possess a numerous set of burnishing tools of their own, which constitutes their stock in trade, and, by rendering them in some measure independent of the manufacturer, enables them to command very fair wages.

After polishing and colouring, the articles are taken to the warehouse, where they are wiped with wash leather and wrapped in paper.

WROUGHT IRON.

ALTHOUGH the number of metals at present known to the chemist falls little short of fifty, there are only comparatively few of them employed for fashioning into articles for use or ornament; and of these, again, a very limited number only come more immediately within the sphere of our observation here—viz., *copper*, *iron*, *lead*, *nickel*, *tin*, and *zinc*. *Aluminium*, which has only quite recently been introduced among the malleable metals, has not as yet been turned to any important practical uses on a large scale; *antimony* and *bismuth* are rather too brittle for working them in the simple state, and the alloys into the composition of which they enter are mostly treated in the same way as

brass and German silver; the application of *platinum* in the shape of vessels, &c., is almost entirely restricted to chemical and other scientific purposes; whilst *gold* and *silver*, lastly, are mostly reserved for coin and articles of luxury, the manufacture of which latter does not materially differ from that of plated articles.

Copper, zinc, and nickel, have been fully discussed in the three preceding articles; of *tin* we shall have occasion to speak in the course of this article, which we purpose to devote more especially to the consideration of one of the principal states in which *iron*, the most important and most practically useful of all metals, is employed for manufacturing purposes.

Iron is a metal of a bluish-gray colour; in the pure state—in which, however, it is rarely seen—it looks almost white when polished, and has a brilliant lustre. It has a dull fibrous fracture. The specific gravity is 7·8. It is the hardest of the malleable and ductile metals, and the most tenacious of all metals, an iron wire of $\frac{1}{36}$th inch in diameter bearing a weight of 60 lbs. In the pure state it requires the strongest heat of a wind furnace for its fusion; but when combined with a certain proportion of carbon, a much lower temperature will suffice to fuse it. English hammered iron, for instance, which is pretty free from carbon, requires a heat of above 2900 degrees Fahr.; whilst the so-called white cast iron, which contains a comparatively large proportion of carbon, fuses at about 1900 degrees Fahr. Steel, again, is much less fusible than cast iron, but much more so than malleable iron.

Iron does not rust in dry air at common temperatures; but in moist air, or under water, it becomes speedily covered with a coating of black oxide or rust. When heated to redness, in contact with the air, a film of oxide forms on the surface, which scales off under the blows of the hammer.

To give a detailed description of the production of iron from its ores, and enter into the statistics connected with the subject, would scarcely be in accordance with the intention of the present article.

Iron may truly be called the *most precious* of all metals; it is certainly the most beneficial to man, and its uses are infinite; indeed, there is not a branch of human industry that could well afford to dispense with its aid and services; nearly all the tools, implements, instruments, and engines

used by man are wholly or partly made of it; and the assertion that, were we compelled to the choice, it would clearly be to our interest to give up all the other metals for the sake of retaining possession of this one, involves no paradox.

Iron is employed in constructive manufacture principally in three different forms or states—viz., as *wrought* or *malleable iron*, *cast iron*, and *steel*; of which two latter we shall hereafter have occasion to give some account; we therefore purpose confining our remarks here, for the present, to the subject of *wrought iron*, which we will now at once proceed to consider in connection with our visit to the

DARTMOUTH WORKS, BIRMINGHAM.

The proprietor of these works, Mr. David Jones, enjoys a well-deserved reputation for the excellence of the wrought iron, hollow ware, galvanised iron goods, patent metallic casks, kegs, tanks, &c., made in his establishment. We beg to offer our best thanks to that gentleman for kindly conducting us over the entire range of his extensive premises and works, and affording us every desirable information.

Malleable iron is prepared in England from cast iron by a series of operations having for their object to eliminate from the latter the carbon in the form of carbonic oxide gas, and the silicon, sulphur, phosphorus, and other foreign bodies in the form of oxidized products, which pass wholly or partially into the cinders. The limited space at our command precludes our entering into a more detailed description of these operations.

The malleable iron of commerce always retains traces of carbon, silicon, &c., which, however, do not detract much from its practical usefulness. The principal and most essential difference between malleable iron and cast iron consists in this, that the former is fibrous in structure, and not crystalline and brittle as the latter. If malleable iron is exposed to continued violent concussion, its toughness becomes speedily impaired, and the fibrous character of its structure changes back to the crystalline structure of cast iron.

The manufacturer of wrought iron hollow-wares, &c., procures the bars or rods and plates or sheets which he wants, from the iron-master. The first operation is to cut

the wrought iron plates or sheets into the required shapes; this is done with huge bench-shears, technically termed *guillotine shears*, which are worked simply by hand; they are made of the best tempered steel, and are apparently so little affected by the hard wear and tear of the edges in cutting through endless successions of tolerably stout iron plates, that they want sharpening only once every three months. The disks for rice-bowls, sugar bowls, tops and bottoms for iron casks, &c., are cut to shape by circular shears, which can be set to any gauge required. Frying-pans, bowls, and a variety of other articles are stamped in dies. In Mr. Jones's establishment there are five stamping machines in active operation; three of these are of the usual kind, whilst the other two are, to all intents and purposes, steam-hammers, upon Nasmyth's principle. The former serve principally for the stamping of frying-pans and work of a like description, whilst lids for kettles and saucepans are stamped by a less expensive machine, worked by hand; the latter, which are fitted with all the recent improvements, are used for deep bowls, &c., and also for tops and bottoms of casks, &c. On the occasion of our visit to Mr. Jones's works we had the opportunity given us to watch the several operations and processes that are required to make that most familiar of culinary utensils, the frying-pan. The first step in the manufacture of this article is, to heat the disked plate to redness, and then to place it in that condition on the lower or bed die of the first of three stamping machines, standing side by side in a row; the hammer or drop, which bears the upper or counter die, is then released, by drawing forward the trigger or lever, and let fall upon the lower die, on which the disked plate lies. As the drop falls from a considerable elevation, the violence of the blow makes it recoil and bound upwards some distance; to prevent injury to the article and dies, which would be sure to result if the hammer were allowed to fall down again and deal reiterated blows, the drop on recoiling is caught by a pair of pall levers, locked into racks fixed on the sides of the upright standards of the machine. The shallow pan is now rapidly shifted, by means of tongs, from the first to the second machine, and stamped again, to bring it nearer the required depth; from the second machine it is then again shifted, in the same way, to the third, where it receives the final blow of the stamp. To

mere superficial observation the pan looks now as if it required only paring the rough edges, and putting on the handle, to make it fit for use. This is, however, very far from being the case; on the contrary, it is only now that the real work begins. It has already been stated that violent concussion tends to impair the toughness of wrought iron, and to change the fibrous structure back to the original crystalline and brittle structure of cast iron. Now, this result is produced in the wrought iron disk, by the powerful blows of the stamping machines; to correct this and restore the iron to its proper condition, and also to prepare it for the subsequent operation of tinning, the pan is re-annealed, and then subjected to a systematic process of hammering, in which the hammer is made to fall with the greatest possible uniformity upon one spot, the pan being moved about beneath it until every part of it, from the centre to the edge, has passed under the pane of the hammer. When this has been fully accomplished, the rough edge or rim is properly pared, and the pan thoroughly scraped with an appropriate iron tool, to remove every scale of oxide. It is then hammered once more, and after this taken to the mounting-shop, where the handle, forged out of a wrought iron bar or rod, is firmly riveted on. A great many attempts have of late been made at simplifying the manufacture of frying-pans by introducing the aid of machinery, but hitherto without success. Of the process of tinning we shall presently have occasion to speak.

The rice-bowls, sugar-bowls, &c., are stamped, as already stated, under the steam-hammer, a machine constructed upon the principle of Mr. Nasmyth's glorious invention. The limited space at our command will not permit a detailed description of this most ingenious piece of mechanism, and we must therefore rest content with presenting to our readers a few brief particulars of the mode of its working. It is constructed somewhat after the fashion of the ordinary stamping machine, with upright planed standards, which serve as guides. The drop or hammer-block is connected with a piston-rod coming out at the bottom of a cylinder in which the piston works. High pressure steam is let in over the piston, which raises it, together with the hammer attached to it, to any required height within its vertical range of motion between the two planed guides. When the valve of the cylinder is opened the steam escapes, and

the hammer, with the upper die attached to it, falls on the disked plates that lie on the lower die, dipping with unerring precision into the central parts, and converting the flat plate into a bowl of greater or less depth. The force with which the hammer is to descend may be measured to a nicety, by simply regulating the escape of the steam from the cylinder. The deep rice-bowls, &c., require, of course, several stampings with different dies before the full depth is attained, after which they pass through the same processes of annealing, hammering, &c., as frying-pans.

The stamped tops and bottoms for casks, kegs, buckets, cornbins, &c., are taken to another department of the works, where they are properly joined in the various ways, by seaming, soldering, riveting, to the body and other parts of the vessel to which they belong; thus, for instance, the bottom of a bucket is seamed on, and the hoop then driven on to it. The heads of large casks for shipping cements, white-lead, oils, &c., are generally secured with screw-pins. Iron kegs and casks are now in extensive demand both for fluids and dry goods, as they present decided advantages over wooden casks, being much more durable and secure.

In the brazier's department are made tea-kettles, saucepans, and other culinary utensils, sugar-boilers for the West Indies, and a variety of other articles too numerous to mention. The spouts of tea-kettles are made to assume the curved form in which we see them in the finished article, by filling the straight tube with molten metal, which is poured in at one end, the other end being stopped up with a paper plug, and when the metal has become solid, hammering the spout into the required shape, after which it is placed in the fire to get out the fusible metal. The process of soldering is conducted pretty nearly in the same way as for brass articles.

Conical sockets for bowls, saucepans, &c., are forged out of flat iron bars; the iron bar is spread sideways, or to an angle, with the pane of the hammer; it is then bent, in the greater proportion of its length, within a semicircular bottom tool, which operation is also performed with the pane of the hammer; the socket is then still more curled up by blows on the edges, and subsequently finished upon a taper-pointed mandrel, which gives the socket the desired conical shape, with the two edges slightly overlapping at the mouth.

The edges are then welded together, either in their entire length or only at the end, to the extent of one or two inches, in which latter case the pane of the hammer is used to draw together the unwelded portion of the edges. In the smith's shop are made also, besides handles and sockets, a variety of other articles, such as hoops, bucket bails and ears, &c.

The forging is mostly done by hand. A *lift-hammer* is, however, also employed in the smithy, which is worked by foot. This instrument is called "*the Oliver*." The hammer-head is about two and a half inches square and about ten inches long; it has a swage tool with a conical crease attached to it, a corresponding swage being fixed in a square cast iron anvil block, about twelve inches long and broad, and six inches deep, with several round holes for punching, &c. The hammer handle is from two to two and a half feet long, and mounted in a cross spindle of nearly equal length, which is supported in a wooden frame between end screws, to adjust the groove in the hammer face to that in the anvil block. To the right end of the hammer axis is attached a short arm about two inches long, from which proceeds a cord to a spring pole over head, and a chain to a treadle a little above the floor of the smithy. When left to itself, the hammer handle is raised by the spring to a nearly vertical position, from which it is very readily brought down with the foot, giving heavier or lighter blows according to the degree of force with which the foot is pressed down upon the treadle.

Some of the articles made of wrought iron, such as kegs, casks, corn-bins, bushel measures, &c., are painted generally blue or green, or, brown, with black hoops, &c. The painting shop contains a large drying stove, heated by steam supplied from the boiler, in which the painted articles are dried. As regards japanning, we shall have occasion in the next article (on tin plate) to give a detailed description of this process.

Frying-pans, bowls, and a variety of other articles, are coated over with tin, to protect them from oxidation.

Tin has a silvery white colour, inclining slightly to yellow. It is very malleable, and may be laminated or beaten out into foil about the thousandth of an inch in thickness, and even much thinner (*white Dutch metal*). It is not very

ductile. The specific gravity of the pure metal is 7·29. When bent or twisted, it emits a peculiar creaking or crackling sound, to which the name of "tin-cry" has been given, and which is occasioned by the friction of the crystals on each other. When a bar of tin is rapidly bent forwards or backwards several times running, the temperature rises, and if the same operation is continued the bar becomes at last so hot that it cannot be held in the hand. When rubbed, tin exhales a peculiar odour; it has also an unpleasant taste. It melts at 442 degrees Fahrenheit, and contracts slightly on consolidation. When heated to redness, with free access of air, it rapidly absorbs oxygen.

There are only two ores of tin, the so-called tin-stone, or Cassiterite, and the sulphide, of which the former alone is found in sufficient abundance for metallurgic purposes. The principal localities in which it is found are, in Europe—Cornwall, Bohemia, and Saxony; in Asia—Malacca, Banca, and Billitan. The quantity of tin produced from the ore in Cornwall and Devonshire amounts at present to about 7000 tons per annum.

Tin is one of the most cleanly and sanitary of metals, and is largely consumed as a coating for culinary vessels, &c. In the pure state it is commonly used for dyers' kettles, and for tubes for gas-fittings, and other purposes; the bearings of locomotive carriages and other machinery are also occasionally made of tin. It is extensively used, besides, in the shape of tin-foil, for silvering looking-glasses by amalgamation with mercury, and for electrical and many other purposes.

It constitutes an important element in many alloys, imparting hardness, whiteness and fusibility to them. It is the basis and principal component of the several varieties of pewter, also of Britannia metal. The better sorts of pewter generally contain about 80—84 parts of tin to 16—20 of lead, occasionally also a trifling proportion of zinc, antimony, &c. The finest pewter, known in the trade as "*tin and temper*," is made of tin, with a very small proportion of copper. Britannia metal contains 900 parts of tin to 64 of antimony, 18 copper, and 18 of brass. It is also largely used for solder; the common plumber's solder, which melts at about 500° Fahrenheit, consists of 1 part of tin to 3 of lead; the fine tin solder, which melts at 360° Fahrenheit, contains 2 parts of tin to 1 of lead. One of the most

important uses of tin is for the manufacture of tinned iron plates, of which we shall have occasion to speak in the next article.

The wrought iron articles intended to be tinned, are taken to the "*tinning*" department—a large thoroughly ventilated shop, with a number of vats containing dilute sulphuric acid, technically termed "*pickle*," and several "pots" containing molten tin, covered with a layer of some oily or fatty matter, or some other suitable material, to keep the surface of the liquefied metal free from oxidation. The articles which it is intended to coat with tin are first placed in the pickle, which thoroughly cleans them; the action of the acid being aided by the application of a gentle heat, obtained by blowing in the steam from the boiler of the engine of the establishment. When the pickle has done its work, the articles are well washed in water, properly dried, covered on the surface with powdered resin, and then dipped into the tin bath; they are finally wiped and rubbed with hurds. If a vessel is simply to be tinned on the inner surface, it is after pickling, &c., in the usual way, heated, and a portion of the molten metal having been poured in, the vessel is swung and twisted about to apply the tin on all sides; after which the excess of the latter is returned to the pot.

Lastly, the bright parts of stoves, and similar articles in wrought iron, are sometimes ground, but generally filed, draw-filed, rubbed with an emery rubber, and ultimately burnished with a two-handed burnisher, with a leather strap or bridle attached on both sides of it, which serves as a stirrup for the workman's foot.

TIN PLATE.

"ONE of the most important manufactures in iron is that of articles in tinned sheet iron, or, as it is more commonly called, *white iron*, or *tin-plate*.

"*Tin-plate* consists of sheet iron, rolled out to various degrees of thinness, and coated on both sides with a layer of tin, which forms with the iron an alloy uniting the useful qualities of both metals. The physical and chemical characters, and the uses of both iron and tin, have already

been given in the article on wrought iron. The process of tinning iron, no doubt, is not the same in all establishments, and the manufacturers of the article even affect a good deal of mystery upon the subject; still it may safely be averred that the different methods pursued at different works agree pretty nearly in all essential points, and the following may be taken as a tolerably accurate description of the process most generally adopted at present:

The best sheet iron (*charcoal iron*) is used for tin-plates. The sheet iron coming from the plate mill is cut with shears into rectangular plates of different sizes, which are piled, with a little sawdust sprinkled between each plate, to keep them separate; the pile is immersed in dilute sulphuric acid, an operation which is technically termed "pickling." In four or five minutes the plates are taken out of the pickle, piled on a stand, covered with a cast iron box, termed an *annealing-pot*, and exposed in this to a dull red heat in a reverberatory furnace for twenty-four hours. This process of annealing, which was first introduced by Mr. Thomas Morgan, in 1829, is a vast improvement upon the old method of bending each plate separately by hand into a saddle, forming two sides of a triangle, and placing the bent plates in the furnace. The annealed plates, when cold, are passed between hard polished rollers; this process of cold-rolling, it would appear, tends to "harden" the metal a little too much, and to impair in some slight degree its ductility; to remedy this defect, therefore, the plates are annealed again at a low heat; after which they are washed in dilute sulphuric acid to clean away the scales of oxide of iron that may have formed on the surface; this latter operation is assisted by a gentle heat of 90 or 100° Fahr., for which purpose the leaden cistern containing the pickle is generally placed over a heated flue. Care must be taken not to leave the plates too long in the pickle, lest they should become stained or *blistered*. From the pickle the plates are transferred to a cistern filled with clean water, and scoured with sand and hemp or hurds. The plates are now perfectly bright and chemically clean on the surface, which is an indispensable condition for the adhesion of the tin. In this state they may be kept for months immersed in pure water without rusting; but a few minutes' exposure to the air rusts them.

The process of tinning is conducted in a building specially

fitted for the purpose; this building is called the *stow*. It contains six cast iron vessels of various sizes, with proper fire-places beneath each of them. These vessels, which are technically termed "pots," are arranged in a row from right to left. The extreme right is occupied by the first pot, called the *tinman's-pan*, which is full of melted grease; the plates having been taken to the stow, with all proper care to keep the surface perfectly bright and chemically clean, are immersed in this grease pot (No. 1), and left there until all aqueous moisture is evaporated upon them, and they are completely covered with the grease. After this they are taken to the second pot, called the *tin-pot*, containing a melted mass of about ten cwt. of block and grain-tin, in nearly equal proportions, covered with a layer of melted tallow, about four inches deep, to protect the molten metal from contact with the air; into this bath the greased plates are plunged in a vertical position to the number of several hundreds, and kept there for a space of time varying from one to two hours, the bath being kept at as high temperature as it will bear without firing the grease. As the surface is not uniformly covered in this first dipping, the plates are transferred from the tin-pot to another vessel, called the *washing* or *dipping-pot*; this is divided into two compartments, a larger and a smaller, each of them containing a bath of molten tin (best grain-tin) covered with grease. The plates are plunged first into the bath in the larger compartment, and left there a sufficient time to get the surfaces uniformly coated with tin. A long table stands between the *tin-pot* and the *dipping-pot*; to this the plates are now removed for the purpose of being wiped on both sides with a hempen brush, after which they are dipped in the second compartment of the wash-pot, which contains the purest tin. After the washing of a certain number of plates, say 15,000, the contents of the second compartment, having suffered some deterioration from becoming mixed with a slight proportion of the iron and tin alloy formed, are removed to the first compartment, and thence again to the tin-pot, the wash-pot being replenished with a fresh quantity of grain-tin. The tinning is now complete, but the plates still require a species of annealing, to prevent the alloy on the surface of the plate cooling quicker than the iron, or otherwise the face of the plate would be sure to be cracked; besides, the superfluous tin must also be allowed

to run off. For this purpose the plates are removed to a large cast iron vessel, called the *grease-pot* (grease-pot No. 2), which contains clean melted tallow, or unsalted lard; this part of the operation requires the neatest management as to the temperature of the grease, which must neither be too high nor too low for the intended purpose. The pot has pins fixed within it to keep the plates asunder; as soon as five plates have been transferred to it, the lad who assists the workman lifts the first plate out and transfers it to a fifth pot, called the *cold-pot*, filled with tallow, heated to a comparatively low temperature; as soon as the workman puts a sixth plate into No. 4, the boy removes the second to No. 5, and so on. The plates are left in No. 5 until they are cold enough to be handled. As they are placed vertically in the several baths, a *list* or *selvage* of tin adheres to the lower edges. To remove this, the plates are now, lastly, dipped in the so-called *list-pot*, a cast iron vessel, which contains only a small quantity of melted tin, sufficient to cover the bottom to the depth of a quarter of an inch; in this bath, which is kept at a rather high temperature, the plates are left until the list or wire of tin is melted, when the plate is taken out by the boy, and the list detached by a smart blow with a stick. The plates are now finally cleansed from grease by rubbing with dry bran, and then sorted according to quality and size, and packed up in boxes. There are now some twenty different qualities in common use, distinguished by certain marks attached to the boxes; the standard for quotation being what is technically called "Common, No. 1," viz., 225 plates, 13¾ by 10 inches, weighing exactly one cwt. in a box.

The plates so prepared are worked up by the tinman, or tin-plate worker, into a great variety of articles of culinary or domestic use, about which we will now proceed to say a few words, in connection with our visit to the

TIN-PLATE, JAPANNING, AND PAPIER MACHÉ WORKS, OF LOVERIDGE AND SHOOLBRED, MERRIDALE STREET, WOLVERHAMPTON,

which Mr. Loveridge, the only surviving partner, and sole representative of the firm, kindly permitted us to inspect, attended by one of the gentlemen on the staff of the

establishment, who proved a most competent guide, and most courteous and obliging withal.

To give our readers some notion of the extent and importance of these works, we need only state, that the number of different compartments, many of them very large, nearly reaches one hundred. The whole of the buildings, which of course cover a large area, are constructed chiefly of iron and bricks, the partition walls of corrugated iron, the staircases of stone and iron. In short, scarcely a chip of wood has been used in building this large factory, which may therefore fairly be considered fire-proof.

An infinite variety of articles of domestic and culinary use are made here of tin-plate, such as baths of every description, coal-scuttles, scoops, cinder-baskets, lamps and lanterns, meat-screens, saucepans, stewpans, graters, tea-kettles, coffee and tea-pots, trays, candlesticks, pails, buckets, cans, &c. &c. Many of the processes and operations are the same, or nearly so, as those described already in the article on wrought iron. The tin-plate is cut into the required disks, strips, &c., by means of circular or rotary shears, susceptible of being set to any gauge required. A great deal of the work is done in the stamping shop, which contains a number of stamps, some worked by hand, others by steam. Among the articles raised by stamping may be mentioned dish covers, which require several repetitions of the process; they must be annealed each time, otherwise the next blow of the stamp might break the plate. When they come from the stamp they are puckered and full of wrinkles, which are *wheeled* out of them between rollers, moving in opposite directions, six covers being placed under the rollers at a time; the smaller rollers are worked by a treadle, the larger by hand, which is very hard work indeed, and might certainly be more advantageously done by steam power. The so-called Victoria Regia Hip-baths (a patent of Messrs. L. & S.'s), and other baths, have now a large hollow semicircular beading put on round the edge, with the hollow overlapping the edge inside, which effectually prevents the water splashing over the rim of the bath; this large beading is made by the stamp, in pieces some eighteen inches long, which are afterwards joined together. The metal spouts for coffee and tea-pots are stamped in two parts, which are afterwards soldered together. Lids and covers for kettles, &c., are also executed by the stamp.

Lamp-bowls, stewpans, saucepan lids, are first raised by the stamp, then burnished to form in the lathe (see the article on German silver).

Cylindrical and conical vessels are mostly formed by stamping. The process of hollowing mouldings was formerly performed on blocks of wood, with wooden mallets, but a very simple and ingenious machine is now generally employed for this purpose. This machine consists of three cylindrical iron rollers, fixed in an iron frame; two of these rollers are connected by toothed wheels, so as to travel in opposite directions, exactly the same as a pair of laminating rollers for sheet metals; the third or upper roller is placed above and just opposite the other two, but is not connected with them, and is accordingly free to move on its pivots. This upper roller can be raised or lowered at pleasure, to modify the diameter of the cylindrical vessel; by placing it out of level, *i. e.* with one end higher than the other, the conical curvature is given to the strip of metal subjected to the action of the machine. The top-edges of culinary and other vessels are generally turned down and folded over wire to stiffen and strengthen them; the upper roller of the bending or forming machine and one of the lower ones are therefore turned into semicircular grooves, to receive the thickened edge which contains the wire; sometimes the rollers are employed also for preparing the seam or fold to contain the wire. The beadings, which are occasionally placed upon the edges of vessels, are made in a species of draw-bench, much in the same way as tubes, and are then slit open in the seam to the width required, according to the thickness of the edge. These beadings are now made of Britannia metal, the application of which is of comparatively recent date, and considered a great improvement.

The perforated disks, &c., for strainers, percolators, &c., are now mostly procured from the so-called metal perforators, whose particular line of business it is to supply them to the tin-plate workers (see the article on zinc).

The process of seaming, soldering, and riveting the several parts of the tin-plate vessels, &c., having been described already in the preceding articles; we may now at once proceed to speak of another important process which many of the tin-plate wares have still to go through before they are ready for the market, viz., the process of *Japanning*.

Japanning is a method of varnishing or lacquering articles in metal, wood, and other materials, originally practised by the Japanese, with a peculiar lacquer, the juice of a tree which grows in the Japanese islands. This juice is obtained by making incisions in the lower part of the trunk; it looks like cream when first oozing out, but turns speedily black in the air. The dried juice, which possesses the property of hardening better than any other lacquer, is occasionally brought over to this country, but hardly ever employed now in the process of japanning as practised here, which differs from the ordinary method of varnishing simply in this, that after the application of every coat of colour or varnish the object so coloured or varnished is dried in an oven or chamber, called a stove, and heated by flues to as high a temperature as can safely be employed without injuring the articles, or causing the varnish to blister or run. By this method two objects are attained, viz., in the first place, all articles so japanned, or, to use the technical term, "stoved," are more durable than they would be if simply left to dry in the air; and, in the second place, a considerable saving of time is effected, which tends to cheapen the cost of the goods.

For black grounds, drop ivory-black mixed with dark coloured animé varnish is used; for coloured grounds, the ordinary painter's colours, ground with linseed oil or turpentine, and mixed with animé varnish. The colours most in use are white lead, Cobalt blue, King's yellow, vermilion (used more particularly to imitate tortoise-shell), Indian red, verdigris, umber, and the intermediate tints produced by mixing two or several of them together. The varnishes most used are animé and copal. The grounds and varnishes are generally laid on with painting brushes, or flat brushes made of fine soft bristles. Tin-plate articles intended for japanning, are first thoroughly cleansed from every trace of grease that may adhere to them, with turpentine or spirits of tar, then rubbed with sand-paper. They are then ready to receive the first coat, after which they are thoroughly dried in the stove.

For black japanned works, the ground is prepared with a coating of black made as just now stated, by mixing drop ivory-black with dark-coloured animé varnish, which gives a blacker surface than would be produced by the japan alone; and the object is then dried in the stove. From three to

Six coats of japan are afterwards successively applied, the work being always thoroughly dried again in the stove between the laying on of every fresh coat.

For brown japanned works, umber is mixed with the japan to give the required tint, the process in all other respects being the same as for black japanned works.

For coloured works no japan is used, but they are simply painted with the ordinary painter's colours, prepared as just now stated.

The colours are protected against atmospheric influences, and made to shine with greater brilliancy, by two or three coats of copal or animé varnish. Superior articles receive as many as five or six coats of varnish, and are finally polished.

The ornamentation of all such articles as come under the head of Toilet Wares, is effected by the ordinary mode of painting with the camel's hair pencil, or some fitting substitute; where imitation of woods or marble is intended, the ordinary grainer's tools are used. Many patterns are produced upon the various articles by a process identical with that employed in the potteries, viz., by what is technically called "*transfer printing.*" The designs are etched on copper-plates, and printed on a species of tissue paper in the required colour, the paper is then placed with the printed side upon the part of the object which it is intended to ornament, and rubbed down upon it with a flannel rubber; the paper is then washed away with water, which leaves the design intact. The composition of the ink or colour used for transfer printing is a subject on which it would appear some mystery is affected by the printers; there can be no doubt, however, that boiled linseed oil forms one of the chief ingredients.

Gilding is executed by pencilling the design on the object with japanner's gold size, and when this is nearly dry, but still clammy, covering it with gold-leaf, burnishing with agate or bloodstone, and highly varnishing with copal varnish. The parts which are to be in dead gold (called *matt*), are left unburnished, and a thin coat of size or glue, slightly warmed, is passed over them.

We will now, in conclusion, give a brief description of the manufacture of articles in *papier mâché*, which is carried on by Messrs. Loveridge and Shoolbred, in connection with their tin-plate and japanning works.

There are at present five principal varieties of *papier mâché* known in the trade, viz.—1. Sheets of paper pasted together upon models; 2. Thick sheets or boards produced by pressing ordinary paper-pulp between dies; 3. *Fibrous slab*, which is made of the coarse varieties of fibre only, mixed with some earthy matter, and certain chemical agents introduced for the purpose of rendering the mass incombustible; a cementing size is added, and the whole well kneaded together with the aid of steam. The kneaded mass is passed repeatedly through iron rollers, which operation serves to squeeze it out to a perfectly uniform thickness; it is then dried at a proper temperature; 4. *Carton pierre*, which is made of pulp of paper mixed with whiting and glue, pressed into plaster piece-moulds, backed with paper, and, when sufficiently set, hardened by drying in a hot room; 5. *Martin's Ceramic papier mâché*, a new composition, patented in 1858, which consists of paper-pulp, rosin, glue, drying oil, sugar of lead, mixed in certain fixed proportions, and kneaded together; this composition is extremely plastic, and may be worked, pressed, or moulded into any required form. It may be preserved in this plastic condition for several months by keeping the air away, and occasionally kneading the mass.

The first-mentioned variety of *papier mâché* alone engages our attention here. A special kind of paper, of a porous texture, is manufactured for this purpose. An iron mould of somewhat smaller size than the object required is greased with Russian tallow, a sheet of the paper is laid on to the greased surface of the mould, and covered over with a coat of paste made of the best biscuit flour and glue, which is spread evenly all over the sheet with the hands, another sheet is then laid on, and rubbed down evenly, so that the two sheets are closely pasted together at all points. After this the mould is taken to the drying chamber, where it is exposed to a temperature of about 120°; when quite dry, which it takes several hours to accomplish, it is carried back to the pasting-room, and another sheet laid on with another coat of paste, after which it is returned to the drying chamber, and the same operation is repeated over and over again until sufficient thickness is attained, which for superior articles, such as are manufactured at these works, requires from thirty to forty sheets of paper, and of course as many coats of paste between. The shell is then removed

from the mould, and planed to shape with a carpenter's plane, after which it is dipped in linseed oil and spirits of tar to harden it; this changes its colour from gray to a dingy yellowish-brown tint. The article is then stoved, and seven or eight coats of varnish are laid on (with a stoving after each), which are cleared off each time, any inequalities of surface being finally removed with pumice-stone. The number of drying processes the articles have to go through consume so much time that it takes three or four weeks to fit them for ornamentation, which is applied in bronze-powder, gold or colour, and for many articles also in mother-of-pearl. The ornamentation of these articles is sometimes effected in the highest style of the painter's art. It was in Wolverhampton that Bird, R.A., worked as a "japanner," the technical name given to an "ornamentor;" and we believe some other of our great artists have sprung from the pursuit of this occupation.

The gold-leaf is laid on with a solution of isinglass in water, the design then pencilled on with asphaltum, the superfluous gold removed with a dossil of cotton dipped in water, which leaves intact the parts touched with asphaltum, and the latter is finally removed with essence of turpentine. The cotton pledgets used are of course carefully collected, to recover the gold removed by them. As regards the burnished and the dead parts of the gilding, we refer to the concluding remarks on japanning.

Several coats of shellac varnish are now put on, and the article is stoved at a heat of 280° Fahrenheit, after which it is polished with rotten-stone and oil, and brought to a brilliant surface by hand-rubbing.

Designs in mother-of-pearl are laid on with black varnish, the article is then varnished all over, and the varnish removed afterwards from the design with pumice-stone; a new coat of varnish is then laid on, and the part covering the design again removed with pumice-stone, and the same operation is repeated, the varnish being always removed from over the design with pumice-stone after each fresh coat, until the surface rises level with the design, which it generally takes from eight to ten coats of varnish to accomplish. Ornamental lines, writing, &c., are put on with colour. The inlaying with mother-of-pearl is a most laborious process, owing to the small size of the pieces at the artist's disposal, and the necessity of attending to a proper distribution and

fitting of lights and shades, lest a mere gaudy daub should be produced in lieu of a tasteful design.

Objects ornamented with mother-of-pearl are subsequently coated with several layers of shellac varnish, stoved, and polished.

A great variety of elegant articles in *papier mâché* are made at these works, such as tea-trays, tables, chairs, screens, work-boxes, inkstands, portfolios, &c.

EDGE TOOLS.

ONE of the most important uses of iron is for the manufacture of *edge* or *cutting tools*.

Edge tools are generally made either of *cast steel* or of *shear-steel*; or the body of the tool is made of wrought-iron, the cutting part of tempered shear-steel or tempered cast-steel. Steel is a carbide of iron, that is, a chemical compound of iron, with a very small proportion (about ½ to 1 per cent.) of carbon. In Germany it is produced direct from pig iron, which contains about 4 or 5 per cent. of carbon, not, however, it would appear, in chemical combination, but simply mechanically mixed with the metal. The pig iron is worked in a suitable furnace until the amount of carbon in it is reduced to the proper proportion. The process of decarbonization, though apparently simple, requires great care, skill, and judgment on the part of the workman, and is rather expensive; besides, the product, which is known as *natural* or *German* steel, has always one great defect, viz., iron is produced along with the steel, and becomes intimately mixed up with it throughout the mass, thus destroying its hardening quality.

The English way of making steel is the reverse of the German, the article being produced, in England, by the carbonization of pure malleable iron bars; the process is generally called *cementation*, and the product *converted* or *cemented* steel. The best steel is produced from the iron obtained from the Dannemora ores in Sweden.

The cementing furnace, in which iron is converted into steel, is of rectangular shape; it is covered in by a semicircular arch, with a circular hole left in the centre, 12 inches in diameter, which is opened when the furnace is cool-

ing. A large cone or hood, 30 or 40 feet high, open at the top, is built around it, which serves to shelter the furnace within, also to increase the draught and carry off the smoke. The furnace contains two troughs or chests, technically called "*pots*," made either of fire-stone or fire-brick, and each of them 12 feet long by 3 feet wide and 3 feet deep. They are placed on opposite sides of the grate, which occupies the whole length of the furnace. Two openings in the front of the arch, one above each pot, serve to admit and remove the bars. These openings are about 8 inches square; a piece of iron is placed in each, upon which the bars slide in and out of the furnace; a third, much larger opening, in the middle, between the two pots, serves to admit the workman who charges the pots. The grate is open at each end, where it is supplied with fuel (coal); the flame rises between the two pots, and passes also below and around them, through a number of horizontal and vertical flues and air-holes leading to the chimneys. The pots are, of course, charged before the fire is lighted. The workman enters by the large opening in the middle, and proceeds to charge the pots with alternate layers of charcoal powder and iron bars. The charcoal powder or dust used in the process is technically called *cement;* charcoal made from hard wood is generally considered the most suitable; some manufacturers, however, use soot instead; others, a mixture of nine parts of charcoal dust and one part of ashes; some add also a little salt. The workman spreads a layer, about two inches deep, over the bottom of the pots; on this he places a layer of iron bars, which he lays down flat, near each other, except those next to the side of the pot, which he places an inch from it; he then spreads another layer of charcoal dust, about an inch thick, over the bars, then again a layer of bars, and so on, alternately, up to within six inches of the top. The top is now covered over, first with a layer of charcoal about an inch or an inch and a half thick, then loamy earth, four or five inches thick, so as to cement the whole closely down, to ensure entire exclusion of the air. The full charge is about 10 or 12 tons.

The fire is now lighted below and between the pots, and the iron gradually heated. It takes about four days to heat it through; the furnace has then attained its maximum heat, which is maintained for two or three days; after this a test bar is drawn out, to see how the conversion is going

on. The heat is subsequently regulated according to the degree of hardness which may be required. The process is considered complete when the cementation is found to extend to the centre of the test bar. Eight days generally suffice to convert iron into soft steel, and from nine to eleven days to convert it into the harder sorts.

After the termination of the process, the converted bars are found to have slightly increased, in length the one hundred and twentieth part, in weight the two hundredth part, on an average; on breaking a bar across, the texture is found to be no longer fibrous, but granular or crystalline. The converted bars are also covered with blisters, which were formerly attributed by some to the expansion of the minute bubbles of air within them, by others to dilatation of the metal occasioned by the presence of sulphur, various salts, or zinc; but which it would now appear are simply occasioned by imperfections in the iron, being thrown up in the unsound parts by the dilatation of the metal, and introduction of carbon between those laminæ which are imperfectly welded.

These blisters on the surface have procured for this article the well-known appellation of *blistered steel*. In this state it is not suited for the manufacture of edge tools. To fit it for the latter purpose, it is passed through the process of *shearing* or *tilting*, by which it is made into *shear-steel*, so called, according to some, from its having been much used in the manufacture of shears for cloth mills; according to others, from being originally employed in the manufacture of shears for cutting the wool from sheep.

The blistered steel is prepared for tilting by breaking the bar into lengths of about thirty inches, piling six or eight of them together, and securing the ends within an iron ring, terminating in a bar about five feet long, which serves as a handle. The pile is then raised to a welding heat in a wind furnace, and is covered with sand, which, melting on the surface, and running over it like fluid glass, forms a protecting coat to defend the metal from the oxidizing influence of the air. When the proper degree of heat has been attained, the faggot or pile is removed from the furnace and placed under a hammer, which unites the pieces into a rod or bar, and closes up internal fissures. This rod is then again brought to a welding heat, and in that condition submitted to the action of the *tilt-hammer*, which we shall have

occasion to describe in the course of this article. The effect of this process is to restore the fibrous character of the metal, and to close all the loose parts and seams. Shear-steel is close, hard, and elastic, and retains the property of welding; it is also capable of being polished. It is much used for tools composed jointly of steel and iron.

Shear-steel, though unquestionably vastly superior to blistered steel, is by no means free from defects, not even after having passed through several tiltings; the great inherent defect in it is inequality of texture and hardness, the outer parts of the bars being invariably and unavoidably more strongly carbonized than the inner and central layers. This defect may, however, be cured, and uniformity of texture and hardness ensured throughout the mass, by another process, viz., *casting*.

This process consists in melting blistered steel, pouring the melted metal into cast iron moulds, and subjecting the ingot obtained to the action of the hammer or roller.

The blistered steel is broken in pieces and charged into crucibles made of Stourbridge clay; these crucibles are shaped like a barrel, and fitted with a cover, cemented down with a fusible lute, which melting after a time, makes the joining the tighter. Each crucible can stand three charges a day, after which it is burnt through; the first charge, about 36 lbs., takes from three to four hours to melt; the second charge, about 32 lbs., about three hours; and the third, about 28 or 30 lbs., from two hours to two hours and a half. The furnaces are common brass-founders' air or wind furnaces, each of them just large enough to hold two crucibles. Coke is the fuel used, the consumption averaging 3½ tons per ton of cast steel. There can be no doubt but that the Patent Plumbago Company's crucibles would answer the purpose much better than the Stourbridge clay, and would ensure a considerable saving of both time and fuel.

The ingots are re-heated in an open forge fire, then passed under a heavy helve-hammer, weighing several tons, the blows being dealt gently at first, in consideration of the crystalline structure of the cast metal; but as the fibrous structure is gradually restored, the strength of the blows is increased. The steel is reduced under the helve-hammer to sizes as small as three quarters of an inch square. Smaller bars are finished under the tilt-hammer, and rollers are also

occasionally used, especially for steel of round, semicircular, and triangular sections.

Cast steel is the most uniform in texture and hardness, and altogether best suited for the making of cutting tools, especially of those made entirely of steel. Some sorts of it, however, will not stand the ordinary process of welding, and are, therefore, altogether unfit for tools made jointly of iron and steel.

The total quantity of steel manufactured in England may be said to exceed 50,000 tons per annum, which is more than the total production of France, Germany, and the United States of America together.

We will now proceed to give a brief description of the general process of manufacturing wrought iron and steel into edge tools and cutting instruments, which we had the opportunity of witnessing on the occasion of our visit to

MESSRS. JOHN YATES AND CO.'S MANUFACTORY OF EDGE TOOLS, EXCHANGE WORKS, ASTON, AND PRITCHETT STREET WORKS, BIRMINGHAM.

THE principal part of the business of the firm is done at the Exchange Works, Aston, where some 400 workmen are employed. The premises cover a very large area, and contain two hammer or tilt houses, and a number of forges, cutting shops, grinding shops, &c. We were conducted over the works by a son of Mr. Henry Yates, who kindly afforded us every desirable information, and to whom we beg to express here our best thanks for his courtesy.

The *tilt* or *hammer houses* form the principal, as well as the most interesting part of the works. They are of very considerable size, and contain, besides ten large and two smaller tilt-hammers, a squeezer, a roller, and shears, all worked by steam-power, supplied by five engines and five boilers of about one hundred horse-power in the aggregate, which consume about 100 tons of coal per week.

The tilt-hammers, with their anvils, are set upon substantial foundations of masonry, timber, and cast iron. The hammer consists of two parts, the *helve* or *handle*, and the *head*. The helve, which is about ten feet long, is made of very stout timber, thoroughly seasoned, and secured by strong wrought iron bands; it is fitted into a cast iron

socket, called a hurst, with trunnions cast upon it, which run in iron sockets called boyts. The head of the hammer is made of cast iron, and is firmly secured to the helve; the hammer is raised by means of a succession of *cams*, varying in number according to the lesser or greater number of blows the hammer is intended to strike per minute. The cams (occasionally called also cogs, ears, tappets, or wipers) are fixed in a massive cast iron collar mounted upon a shaft provided with a heavy fly-wheel. The motion is applied at the tail of the helve, by the cams of the revolving collar or wheel engaging the extreme end of the tail, and depressing it until disengaged again in the further progress of the revolution of the wheel, when the head of the hammer falls with considerable force (equal to about one ton weight) upon the anvil. The latter consists also of two parts, the *stock*, which is of cast iron, and rests upon a massive wooden pillar strongly secured by wrought iron rings, and supported by the masonry of the foundation; and the *anvil*, which is of cast iron like the head. The number of blows dealt by the hammer generally varies between 75 and 150, but may be raised to as many as 350 or 400 per minute.

Many edge tools, such as shovels, spades, hoes, mattocks, cleavers, &c., are partly forged and plated under the tilt-hammer. The objects having passed through the preparatory stages, technically termed *moulding*, by ordinary hand-forging, are spread out under the broad face of the tilt-hammer, the work being occasionally greatly facilitated by an ingenious contrivance, viz., a kind of swing, consisting of a board suspended by iron rods from the ceiling; the workman being seated in this swing, is thereby enabled, with a very slight motion of his feet, to advance or recede with ease and rapidity, and place himself at pleasure in front or on either side of the anvil, as the progressive changes of the work may require.

Although the foundations on which the hammers are set are carried to a considerable depth, and consist of a heavy mass of masonry and timber, to diminish the concussion of the blows, yet even a short stay in Messrs. Yates's tilt house, with twelve leviathan hammers actively at work, and their heads, each of them weighing several cwt., falling on an average 150 or 200 times per minute upon solid metal anvils, is by no means over-pleasant, the noise being abso-

lutely stunning, and the vibration felt through the whole body.

In the forging of some tools and implements the *squeezer*, or hinged press, is substituted for the hammer. This engine consists of two powerful jaws, of which the upper is movable, the lower, which forms the anvil, fixed. The movable or working part makes from 50 to 60 motions per minute; it is set in motion by a crank, worked by a large fly-wheel.

The *rollers* are the same as the common laminating rollers of the sheet-iron rolling mills. Their use is confined to inferior articles, all the better sorts of tools being plated under the hammer.

The *shears* consist of two cutting edges or blades of hard steel firmly bolted, one to a fixed frame, the other to a massive lever, which hinges upon an axle, and is attached at the lever end to a connecting rod moved by a crank from the shaft of the engine. At every revolution of the axle the jaws of the shears are made to open and shut alternately, dividing, apparently with perfect ease, iron or steel bars of an inch or more in thickness. We saw them at work upon iron bars three quarters of an inch thick by three inches wide and twenty-feet long, which they chopped up into some forty pieces each with as much ease and in about the same time it would require to take as many bites out of a sponge cake. Whenever the workman who was feeding these insatiate, ever-opening, ever-shutting jaws, came near the end of the bar, we could not help shuddering at the frightful danger of mutilation to which he exposed his fingers, pushing them, with the last short end of the bar between them, close up to the cutting blades. Familiarity with danger is but too apt to breed contempt of danger, as anybody can testify who has had opportunities of visiting large factories. Only a few months before, a frightful accident had taken place at Messrs. Yates's works, an unfortunate apprentice being crushed to death by the wheel of one of the engines; yet we did not observe that the workmen and apprentices on the premises gave a wider berth than usual to the shafting, &c., of the engines.

An almost infinite number and variety of edge tools are made at Messrs. Yates's works, such as adzes, axes, hatchets, pick-axes, bill and pruning hooks, spades, shovels, hoes, choppers, mince-knives, cleavers, augers, tap-borers, chisels, gouges, plane-irons, scrapers, caulking-irons, chaff-knives,

&c. &c., some of them wholly of solid steel, others of steel and wrought iron jointly—that is to say, the body of the tool is made of wrought iron, the cutting edge of steel, which is inserted in a cleft, or between the two tails of a piece, or *mould* of iron folded together, or, as in the case of spades, for instance, between the two moulds of which the tool is made; or, as for plane-irons and socket-chisels, for instance, laid on the outside. The former process is technically termed *steeling in the centre*, the latter *steeling on the face.*

We will now give a brief description of the process of making a hatchet and a shovel of wrought iron and steel jointly. When the bar has been divided by the shears into the requisite lengths, which then receive the name of *moulds*, a mould of proper length and width is selected, heated to bright redness, and a piece of steel welded on to the central part, which is intended to form the pole of the hatchet; one half the length of the mould, on both sides of the central part on which the steel has been welded for the pole, is then thinned and extended sideways into projections, after which the work is folded, at the central part, round a tapering mandrel of the section of the intended eye, and welded across the line of demarcation between the extended portions and the untouched tails. The tapering mandrel is then again introduced into the hole from both sides, which serves to make the eye a little smaller in the middle than at the openings on both sides, so that the handle of the tool, when carefully fitted and wedged in, will always retain a firm hold of it. When the eye has thus been perfected, a slip of the best cast steel, of the required length, is inserted between the two tails of the iron, as yet of their original size, up to the first weld, and all three are welded together to the proper extent. The work is now put into a hollow fire, and the combined iron and steel are then drawn out sideways, to the required width, under the tilt-hammer. After this the tool is flattened and smoothed with the face of the hammer; the hammer-man dips the hammer in the slake trough, and lets fall upon the anvil a few drops of the water which it takes up; when the red-hot metal is now struck upon it, the ensuing explosion of the water serves to detach the scales, that would otherwise be indented in the work. After this the edges are pared with shears to the required pattern, and trimmed with a round-faced hammer or a top fuller.

The parings are used for gun-barrels, &c.

For shovels, two moulds are drawn out at one end into a long strip; they are then laid one on the other, a small triangular space being kept separate by a layer of sand placed between them, to form the *coffre;* after which the two moulds are joined and, with a steel slip inserted between, welded together on all sides, except the strap and the coffre. The shovel-plate is then passed through the rollers, and afterwards tilted or "dickied." The coffre is now opened by the insertion of an appropriate tool, after which the work is set, and cut and trimmed into shape; the holes for the nails and rivets are then punched out, and the tool is finally treed up.

When the tools have arrived at this stage of manufacture they are ready for the grinding-shop, where they are ground, either quite bright, which means ground over the whole surface of the tool; or half bright, or simply at the edges, the unground part being afterwards generally either blued or black japanned. After the tool has been properly ground, it is glazed or well polished with emery. For grinding, Derbyshire and Yorkshire grindstones, of different degrees of density and coarseness, are used. The glazing is done on wooden wheels, covered with leather and charged with emery powder, which are technically called *bobs* or *glazers;* they are generally used dry, immediately after the tool has left the grindstone.

The scrap iron of the works, which of course contains a good deal of steel, is sent back to the iron-foundry, where it is made into a superior kind of iron.

The blast for the forges and hollow fires, &c., is supplied by means of a revolving fan worked by a small steam-engine.

We now come to another important branch of the business, viz., the manufacture of the wooden handles for the tools, which are here made on the premises. They are made principally of ash wood, which it would appear is best suited for the purpose, at least in England.

The timber is sawn into $1\frac{1}{2}$-inch planks; the outline of the intended handle is then traced on the plank, and the shape traced sawn out by a circular saw, after which the rough handle is properly turned in the lathe.

The handles or trees for spades, shovels, hoes, forks, &c., are either what is technically called *eye-tree* handles, which

are made in one piece, or *crutch-tree* handles, which are made in two pieces, the crutch being put on to the top of the handle. The eye-tree handles are cut out with a broader part at the top; a small hole is made in this part with a revolving gouging tool, and the eye is then properly cut out by a small steam saw.

Some handles are bent; to effect this the tree is boiled in water, then put hot into a bending machine, where it is gradually screwed into the desired shape, the screws being worked by hand; the operation is by no means uniformly successful, as even with the greatest care, and every attention to the details of the process, a certain proportion of the trees are always sure to break in the bending.

AGRICULTURAL IMPLEMENTS AND MACHINES.

A DAY AT THE ORWELL WORKS, IPSWICH.

FIFTY years ago the only implements in common use for the tillage of the soil were the plough, the harrow, and the roller. These were of most primitive construction, and had few features in common with the modern implements bearing the same name. In the barn the flail still maintained its place; winnowing machines were here and there to be seen; but the thrashing machine, the drill, the scarifier, now to be found upon every well-cultivated farm, though not absolutely unknown, were regarded generally as objects of curiosity rather than of use. The readers of these pages who are interested in the development of the implement trade will, if we mistake not, read with pleasure any reliable account of the processes and operations by which the most improved agricultural machinery is produced.

Having lately spent a pleasant day at the Orwell Works, Ipswich, now the seat of the manufactory which since the latter part of the last century has been carried on by the Messrs. Ransomes, we propose to give in the following pages a short sketch of the nature and extent of this important business, of the manner in which it is carried on, and of some of the more interesting mechanical processes which are nearly special to it.

It was about the year 1783, when farming was in much

the same condition as it had been from time immemorial, and when the state of the country and the habits of the farmer forbade rapid means of communication between the inhabitants of one district and those of another, that Robert Ransome, then living at Yarmouth, commenced devoting his mechanical ability to the improvement of the plough. The first part of this implement which claimed his attention was the plough-share. Up to that period it had been made in wrought-iron; for no method having been discovered of making cast-iron sufficiently hard to endure the work, there was no other alternative to the farmer but to use a material which, if not harder, at least admitted of frequent resharpening by the blacksmith. It was in the year 1785, up to which period there had only been seven patents ever granted by the English Government for the manufacture of ploughs or their parts, that Robert Ransome took out his first patent for a method of tempering cast-iron plough-shares; and this was followed by a succession of improvements, until, in the year 1803, he patented the process by which plough-shares in cast-iron are produced with the under side as hard as hardened steel, and the upper side of the original softness of the iron. This plough-share, in spite of the difficulties of transit, became rapidly diffused throughout the eastern counties of England, and subsequently spread over the whole island, superseding on account of its cheapness and advantage to the farmer the old wrought-iron share. We have dwelt rather at length upon this patent, because its original success was the foundation of the subsequent business now carried on at the Orwell Works, which has increased until the factory covers nearly thirteen acres of ground with its workshops and yards, and gives continuous employment to upwards of 1100 men and boys, of whom more than 400 are engaged in the manufacture of ploughs only. In the year 1808, Robert Ransome took out a third patent for the wheel plough; the leading feature of which was, that the working parts were easily removable and renewable by the ploughman in the field without requiring the intervention of the blacksmith. Ploughs made on this patent, and each possessing such peculiar modifications as the customs and usages of different localities demanded, rapidly spread throughout the kingdom; and in the year 1839, at the first meeting of the Royal Agricultural Society at Oxford, although no provision had

been made in the early constitution of the Society for promoting the implement manufactures of the kingdom, and no inducement in the shape of medals or prizes was offered, "the Ransomes," to use the words recorded in the Society's Journal, "sent up their wagons laden with more than six tons of machinery and implements, the superior manufacture and the variety of which commanded universal approbation; and amongst which were a variety of ploughs of superior construction."

The following year, at Cambridge, they showed eighty-six different varieties of ploughs, each adapted to the requirements of some particular locality. Four years later, at the Society's meeting in Southampton, they showed a plough on a patent which embraced principles hitherto not applied to this implement—viz., the capability of working equally well upon heavy land or upon light land. For this plough they there received two separate silver medals, and two separate first prizes after undergoing a severe trial; and inasmuch as it is more or less the type of all the numerous varieties of modern English prize ploughs, it is worth while to take some notice of its construction. The beam was composed of plates of iron so trussed together that the utmost stiffness was obtained with the least weight of material. The plough-share was fitted on a movable neck, so that its point could be set more to or from land, or with more or less dip as it wore away; and it was provided with several mould boards or breasts, which differed in curvature according to the nature of the soil, and either of which could be put on or taken off in five minutes. Thus was the farmer on mixed soils relieved from the necessity of purchasing so large a stock of ploughs as he was formerly obliged to do, and a thoroughly standard implement was offered him instead of the wooden plough which he had been previously compelled to purchase. Since that year many thousands of that particular plough have found their way to all quarters of the world, until at last, to meet the varying circumstances under which it has had to work, it is provided with no less than forty varieties of mould board, each of which has a different degree of curvature. We have dwelt at some length upon the plough, because we have no doubt that many of our readers have an idea that the construction of a plough is a task requiring but little mechanical skill, and that the adaptation of a plough to various localities is a

matter of little importance; indeed, we ourselves were not aware, until we visited this factory, of the amount of careful study and mechanical ingenuity which has been expended on every portion of this implement. In moulding the cast-iron parts, machinery involving the combination of three separate patents is employed, the effect of which is to produce castings of exact similarity and of beauty of finish unattainable by any other process. These patents, so far as we know, are not employed by any other firm for this particular purpose. In the forgings, steam and hydraulic power are brought to bear; and the various processes of stamping and punching are made use of wherever practicable. When the wrought and cast-iron parts arrive at the fitting shop, each part is treated individually, and not with respect to its associated parts, but with respect to a pattern die and template, so that the same piece when complete will fit any plough of the pattern to which it belongs, whether it has been made ten years, or five years, or only yesterday. In consequence of this the firm are not only able to supply any new plough, but also to execute repairs at a moment's notice for far distant countries; and so carefully does the supervision of the factory provide for accuracy in this respect, that we were assured that they had had no returns on account of misfit for many, many years.

But although there is so much to interest us in the plough, which, indeed, is one of the staple products of this large factory, we must pass on to another matter of enormous importance to the agriculturist, and to which the firm early directed their attention—we mean the employment of steam in agriculture.

After the success which was early achieved with the plough, the Ransomes were naturally applied to for other machinery, and gradually produced chaff-cutters, root-cutters, dressing machines, and horse-power thrashing machines, for all of which they became more or less celebrated. Even so far back as 1841, now twenty years ago, they showed the first portable steam engine ever exhibited at the Royal Society's meetings. In 1842, at Bristol, they showed a portable steam engine for the purpose of thrashing corn, which was transportable from place to place by means of its own power.

For some years subsequently, however, their business as general engineers, absorbing a very large portion of their

time and mechanical ingenuity in the development of some other processes which we shall briefly notice by-and-bye, the Ransomes did not produce so much that was useful and novel in the agricultural implement trade as the preceding years had witnessed; but the implements which they had already made continued to extend their fame and to increase their business.

In 1846, the firm having gained a very large proportion of the prizes offered by the Royal English Agricultural Society up to that date, and having twice received the Society's gold medal for special excellence—an honour which has been conferred on no other manufacturer from the foundation of the Society to the present time—retired from exhibiting at the country meetings; but, in 1852, they again commenced exhibiting, and in the next seven years again occupied a prominent place in every prize sheet issued by the Society. At the agricultural meetings held at Canterbury and Leeds, in 1860 and 1861, the Ransomes, with other leading implement-makers declined to exhibit, on the ground that the Society rendered competition for its prizes compulsory on all exhibitors, and did not provide sufficient machinery or apparatus for enabling a correct adjudication to be arrived at. All kinds of comments were made upon this step; and so far as the matter was understood by the public, the course adopted by the manufacturers met with considerable approval. As the show of 1862 was one of great importance, the Ransomes, on that occasion, returned to the sheds of the Society, and introduced to the British and Foreign agriculturists who visited Battersea-park their new Victorian reaper.

It is impossible for us here to enter upon a discussion, or to set before our readers otherwise than very briefly the various considerations which have induced these manufacturers to take so important a step as abstaining from their annual appearance at the country meetings of this Society. It will be sufficient, perhaps, to say, that after a long conversation on the subject, in which we endeavoured fully to sift the matter as well as we could, we were satisfied that, so far from desiring to evade any trial or competition with other manufacturers, this firm has only one object in view—viz., to promote such a system of trial as may really elicit the merits of the various competing machines, and may furnish trustworthy data for the guidance of the retailer and

the consumer. Next to the manufacturer, perhaps, no one is more interested in this matter than the retailer. His best experience may tell him that a machine for a certain purpose performs its work perfectly, and he therefore lays in such a stock as he thinks will meet the requirements of his district. The show day comes. After a hurried and imperfect trial, at which, possibly, the machine which he knows to be good was not represented, some fresh machine charming the authorities of the Society by some apparent novelty receives the prize. Forthwith a brief demand is occasioned for the new machine, his old stock becomes heavy and difficult to dispose of; but worse than all that, the new machine which he is thus compelled to supply, having been got up more for the purpose of doing remarkably well for a short time than doing work of average merit for a very long time, not unfrequently breaks down in its work, fails to give satisfaction to the customer, and is ultimately either returned on the dealer's hands, or involves him in unpleasant disputes.

After this brief digression, which, however, seemed to arise naturally in our conversation on the progress of the various implements, we must return to the employment of steam in agriculture; and beginning with the steam plough, we may observe that until Mr. Fowler started a factory of his own, most of the steam-ploughing machinery under that gentleman's patents was manufactured and practically carried out at Ipswich. Although not now manufacturing for Mr. Fowler, the Ransomes still work for their own customers; and we saw a complete set of machinery ready packed for export to one of our Australian Colonies, where, we trust, it may prove to be the forerunner of the new and improved cultivation which has attended its introduction in England.

The portable steam engine receives the special attention of the firm, it being so universally preferred by agriculturists of every country to the fixed engine. We were much pleased with a new patent engine which the firm has recently brought out, in which the defects hitherto inherent in multitubular boilers, or boilers on the principle of the locomotive, are apparently entirely obviated. It is well known that in all the boilers of this construction it has hitherto been extremely difficult to keep them from a deposit of mud, and other matter encrusting the tubes or the fire-boxes; and that when this deposit has once commenced to form, not only is this

followed by an increased consumption of fuel, but also by great deterioration of the plates of the fire-box, until at last the principal drawback in the use of portable engines has consisted in the costliness of repairs required to the fire-box and tubular part of the boiler. In the new engine this is overcome by making the fire-box with the tubes easily removable, and without taking the engine off its wheels or disturbing one of its working parts, thus greatly reducing the cost of such repairs as those we have alluded to. The engine has a light and elegant appearance, and burns less fuel than those on the old pattern. We have little doubt that this engine, when it becomes generally known, will be greatly preferred to those on the old construction, and especially for those localities or countries where repairs are difficult on account of distance from any town where there is a factory.

Leaving the large and spacious building in which these engines are manufactured—which is filled with tools of the greatest ingenuity and of the first quality from the various leading workshops of Lancashire and Yorkshire, and in which we saw both portable and fixed steam engines in every stage of progress—we passed onwards to another large shop devoted to the manufacture of hay-makers, chaff-cutters, and mills of every description, and to one or two of which we must devote a passing remark. In the year 1853 Mr. Biddell, a near relative of the members of the firm, brought out a little mill for the purpose of splitting beans. Prior to this invention there was no mill that would split beans well and quickly when they were damp or out of condition, for the cutting parts of all the mills had been formed of a solid roller, or pair of rollers, toothed on their surfaces; and if the beans were at all damp the teeth clogged up, and the roller became a smooth one, thus losing all splitting power. This difficulty was overcome by forming the barrel hollow, so that the beans, when split, passed between the knives into the interior of the barrel. A further advantage was obtained by making each of the knives triangular and easily removable, so that when one edge was worn out or chipped, it could easily be withdrawn, and replaced with the other edge foremost. Thus each knife having three edges, and being easily removable and renewable without interfering with its neighbours, and at a cost of 3*d.*, all difficulty in the splitting of beans was overcome.

Soon after, Mr. Biddell invented an oat mill, which was also patented by him, and in which the roller was composed of a union of steel and cast-iron. Up to this time the rollers of mills for kibbling oats had been made either of cast-iron hardened, which produced a very worthless article, or of wrought-iron hardened, which produced a very expensive article; but this patent enabled the manufacturers to produce a superior article to either of the above, and at less cost. The process of manufacture, which is patented, is simply this: a series of steel slips are arranged in a particular manner in the mould, and the molten metal is poured in, which unites firmly with the steel, and when cold the roller is turned up and cut, leaving the slips of steel forming the cutting edges. It is then heated and hardened in water, as though it were a solid steel roller; but owing to the cast-iron not hardening in this manner, the steel slips always have a soft tenacious support at their backs, and can therefore be made much harder, without risk of breaking or chipping, than it would be possible to make them if the roller were of solid steel. These two mills, the oat mill and the bean cutter, met with universal approval; and either as separate mills, or combined in one mill, or mounted on the same frame as an oil-cake breaker, they have been sold by thousands both at home and abroad, and the demand for them is every day increasing.

Leaving this shop, we enter a large and spacious building devoted to the construction of steam and other thrashing machines, each pattern of which has some special merit, but of which our space will only permit us to describe at all in detail the patent finishing steam-thrashing machine, suitable for an eight-horse power engine, which is the leading machine now made by the firm. This machine is interesting from many points of view. The whole of the framework is prepared by machinery, all the scantling being sawn, planed, morticed, and tenoned by steam-power machinery, and a marvellous solidity and precision of work being thereby secured entirely superior to anything that can be done by hand labour. There are also three separate patents embraced in the machine, all of which tend to make it perform its work with very little power, and to give it remarkable durability, viz., the patent shaker, the patent drum, and the patent screen, each of which we shall attempt briefly to describe. The machine itself stands on four road wheels,

and its general appearance is light and symmetrical. The front road wheels are carried on a ball and socket-joint, which enables the machine to be placed on uneven ground without wringing or twisting the framework. The thrashing drum is composed of a series of beaters, each of which consists of a bar of iron formed into a triple-threaded screw, each alternate one forming a right-handed, and the intermediate one a left-handed screw. This gives not only a channel-beater which has a perfect rubbing action in no way detrimental to the grain, but permits the beater to be reversible; for when by use the grooves are worn out on one face, the drum is so arranged that by slackening the clips which hold them, each beater can be turned partly round, and a perfectly new face exposed for thrashing. After the straw leaves the thrashing drum it passes on to the shaker, all the movements of which are rotatory, and which performs the three separate operations of removing the straw to the end of the machine, of separating from it any straw which may have escaped separation in the drum, and of carrying back all the short straws and chaff which are hanging in it to the winnowing apparatus which is placed immediately under the drum. In machines with reciprocating or crank shakers these operations require what is commonly known as a jog-board, and which, with its heavy reciprocating movements, absorbs a good deal of power, and causes wear and tear which in this machine are entirely avoided. The thrashed corn and short straws, &c., pass on to a coarse riddle, and afterwards on to another riddle, during which time they are subjected to a suitable regulated blast of air, which, together with the action of the riddles, separates the grain, the chaff, the short straws, and the chobs, into four divisions. The clean grain is then carried up by elevators through a chob-cleaner, which removes any husks that may be still adhering to the grains, and then it passes through an arrangement of sieves combined with a blast precisely similar in action to those of a well-constructed hand-winnowing machine. By this process all seeds and dust are removed, and only one more operation has then to be performed, namely, the separation of the corn into various sizes by the removal of the light or chicken corn from it. This is effected by means of a patent corn screen, which may be made finer or coarser at the pleasure of the user, and which, by its con-

struction being perfectly self-cleaning, is uniformly effective. Previous to the invention of this screen this was a difficult process, inasmuch as the screens hitherto in use either soon became stopped up with grain which was nearly but not quite large enough to pass through them, or they required to be kept clean with brushes revolving inside, or with washers or pickers passing between the wires, each of which contrivances involved loss of power, and was subject to continual derangement through wear. This screen overcomes these difficulties in the most simple and mechanical manner. If our readers will fancy two lengths of wire, each wound on to a cylinder of a different diameter so as to form a screw, and then this thread being supported in such a way that the cylinder could be removed from the inside so as to form two open wire spirals, one smaller than the other, and let them fancy the smallest of these spirals mounted on a spindle and placed inside the larger one, but in such a position that the centre of revolution of the small and the large one were not identical, they will then get an idea of the construction of the screen. The two spirals being mounted as above described, and with an arrangement which permits of the centre of the smaller one being placed either concentric or eccentric to that of the larger one at pleasure and both set in motion, it is evident that the screen will be finer at one end of any given diameter than it is at the opposite end of the same diameter; and the finest part being placed at that part to which gravity naturally carries the grain, it is evident that the centrifugal motion, by the revolution of the cylinders, will keep the screen thoroughly alive, and any grains which stick fast at the bottom will, as they pass round towards the opposite end of the diameter to that at which they stuck come to a wider place, and consequently be liberated and fall down again amongst the other grain which is being screened, so that the screen becomes by its very nature perfectly self-cleaning and free from all those accidents which have hitherto made screens so practically difficult to use. In this invention, simple as it apparently is, some exceedingly ingenious tools and processes are employed, which we regret that our limits will not permit us to describe. We regret this the less, however, because we are informed by the firm that they are at all times glad to show their manufacture to visitors whose references are satisfactory; so that

any of our friends who feel interested in the matter can enjoy the same opportunity of inspecting these interesting processes which we did.

Leaving with regret this department, which we have only imperfectly described, we must briefly notice the manufacture of railway fastenings—a process in which the subdivision of labour is carried to the highest extent with the most successful result. These fastenings consist of a round pin, which holds the railway chair down to the sleeper, and of a key or wedge which holds the rail firmly into the chair. They were invented by the late Mr. May some years ago, and have been very extensively adopted on several English railways, the Great Northern and South Eastern being amongst others entirely laid with them. The pins are made of oak, turned to a given size; then compressed into iron moulds, which reduces their bulk one-fourth; then steamed to prevent their expanding by the simple hygrometric changes of the atmosphere; afterwards pressed out, turned at each end: finally they are packed in casks, and after having passed through fourteen or fifteen distinct processes, are sold at a price slightly over ½d. each. When driven into the sleeper and the ballast thrown over, the dampness of the ballast expands the oak to its original dimensions, and that part of the fastening which is surrounded by the iron eye or hole in the chair not being able to expand, the principal expansion takes place in the sleeper, and thus the most secure fastening takes place which it is possible to imagine. The key being longer than the tooth of the jaw of the chair, the head and part of the point project on each side, which, swelling in like manner, make any movement of the rail or of the key impossible. This branch of the business employs a large number of hands, and is special to this firm. Every part of it, even to the method of counting the treenails, before they leave, is marked by great simplicity and ingenuity. These treenails being sold by the thousand, it was, of course, an object to count them accurately, which is effected by having the casks in which they are packed made nearly of the proper size to hold one thousand. The boxes are then prepared with one hundred divisions, and each of the boys whose business it is to pack is furnished with one of these boxes. Having filled his box and emptied it into the cask, he never has to count more than ten, and inasmuch as nine

boxes will not fill the cask, and eleven boxes full cannot be got in, he practically has no occasion to count at all. The system is so perfect that no complaint of deficiency of count has arisen since it was adopted; whilst before that time, with much more expensive hands, annoying complaints were continually arising.

Although our space is now rapidly drawing to a close, we must take a hasty glance at the pattern-room, which is 100 ft. long and 40 ft. wide, and which is filled with models of the most varied description for the various works, the construction of which has been undertaken by the firm, and for the standard machines which they are now constructing. Every one of these is properly marked, registered, and entered in books, and has its appointed place, so that a stranger, after an hour's explanation and practice of the system, would be able to find any pattern for which he was asked with the greatest ease and quickness. The stores of every description at one end of this building, from which alone issue every year articles of as much value as would make a handsome return for a country ironmonger, are kept in the same exact and beautiful order. The cost office, in which all accounts relating to workmanship and to the cost of manufactured goods are kept, joins the stores. In it are twelve or fourteen young men engaged in the important, but too often neglected, business of ascertaining carefully the cost of everything produced by the firm. The system on which this is done is simple, ingenious, and accurate. The arrangements connected with the payment of the wages, seem to us peculiarly simple. Each man's time at his rate of wages is calculated by a small revolving machine at a most rapid rate, and with perfect accuracy. The amount due to each man is shown in the books, with the various stoppages for sick fund, doctor's club, or other matters to which he may be a subscriber, and for which the firm undertake to keep the accounts, is entered upon a small cheque, which shows the gross sum, particulars of the stoppages, and the nett amount due, which nett amount, together with the cheque, is put into a small bag, each man having his own bag. All the bags being got ready beforehand, the whole time occupied in paying the eleven hundred men rarely exceeds six or seven minutes, and every man can see at once how his wages are calculated, and whether he has got the proper amount which he expected to have.

If he has, he returns his bag and ticket to the office; if he has not, he immediately comes to have the error redressed; but so simple is the system, and so much care is bestowed upon its working, that these errors are of the fewest and most trivial description. Adjoining the manufacturing office is the draughtsman's office—light, comfortable, and quiet. Every drawing is indexed, catalogued, and put away on a definite principle. Every alteration made in it is recorded, and on a system capable of almost indefinite expansion. Arrangements exist by which not only the total work issued from the office in any given period, but the work done by each individual draughtsman, may be concisely and readily ascertained by the superintendent. No extra finish is bestowed upon the drawings, but extreme accuracy and correctness is insisted upon.

Leaving the drawing office we come into the commercial office, in which is a long row of desks, each bearing legibly the name of the occupant, so that a stranger can immediately find the clerk whom he wishes to see. On one side, also, are private rooms for the masters; at the end is a strong room in which all the books of the establishment and its correspondence are kept, and on the walls we see various illustrated diplomas granted by foreign agricultural societies to the firm for the excellence or merit of manufactures which they have exhibited. Having glanced round these, and bestowed a look at the large collection of gold and other medals which have been awarded to the firm, and which include several medals of the first rank from France, Austria, Holland, Belgium and Russia, besides many English ones, we find that our time has nearly elapsed, and that we must be off. We left with a feeling of gratification at all that we had seen, and that a factory in which so many machines and processes were employed should, by the liberal views of its owners, be rendered accessible to those who are interested in its productions.

SHEFFIELD STEEL-WARE.

If it is an axiom in political economy that for a branch of industry to be truly *national* in a country, and to rest on safe and stable foundations, it is indispensable that both the raw material to be worked upon and the converting and

fashioning labour bestowed upon it should be *indigenous*—an axiom the truth of which has been but too painfully demonstrated in our own days by the sudden and sad collapse of our cotton manufacture—our metal works, and more pre-eminently our iron and steel works and manufactures, may safely claim the very highest rank among the many and multifarious branches of national industry in Great Britain, as everything here conducive to absolute success is indigenous of the soil—the ore and the fuel, the bones and sinews, and patient endurance of the labourer, the skill and taste of the artisan, the talent and genius of the artist, the capital and enterprise of the employer, the world-wide business connections of the merchant, and the cheapest, speediest, and safest means of conveyance to all parts of the inhabited globe.

In most of the preceding article we have given our attention more particularly to the metal workshops of Birmingham and Wolverhampton. We will now pay a visit to Sheffield, the great centre of the iron and steel ware industry of Great Britain.

To guard against any possible misconception upon a most important point, we deem it advisable to repeat here what we stated in reference to the Birmingham and Wolverhampton shops, viz., that as we had to choose from among a host of firms of equal eminence in the various branches of manufacture described, our selection of the places visited by us has been guided entirely either by considerations of convenience or by mere chance.

Sheffield is situated in one of the most charming and picturesque parts of Yorkshire. It forms the centre of the great cutlery district, the name of which, "Hallamshire," though rather puzzling to the stranger, as indicating the existence of an English shire not usually mentioned in geographical books, is dear to the heart of every true Sheffielder. An enthusiastic Caledonian will occasionally talk about "that part of Scotland called England;" so enthusiastic Hallamites would seem to look upon the great county of York as a mere appendage to their own dear Hallamshire. Sheffield derives its name from the Sheaf, one of the five small streams by which the town is intersected, and which, even in these days of steam, continue to supply a considerable portion of the motive power used in the manufactures of the town.

The number of trades carried on in Sheffield has increased very greatly in the present century. They now include the general manufacture of iron and steel—railway and carriage springs, buffers, tyres, &c.; heavy ordnance, steel bells, steel wire, crinoline, files, saws, edge tools, scythes, sickles, table and pocket-knives of every kind and description, scissors, shears, razors, skates, spades and shovels, axes, hatchets, surgical instruments, machine fittings, steel collars for shirts; silver, silver-plated, and Britannia metal wares; brass chandeliers, stoves, grates and fenders, optical instruments, &c. &c. But it is as the world's cutlery mart that Sheffield is more popularly and prominently known. From time immemorial the town has been associated with the manufacture of cutlery; there are even traditions that it supplied the Ancient Britons with weapons to combat the Roman legions. At all events, the celebrity of the city for its steel manufactures can be traced back by authentic records as far as the twelfth century; and Chaucer writes of one of the characters in the "Canterbury Tales," "A Sheffield thwytel (whittle) bare he in his hose." The number of eminent persons engaged in the manufacture of cutlery in Sheffield is very considerable. We have selected from among them for description

THE QUEEN'S PLATE AND CUTLERY WORKS OF MESSRS. MAPPIN BROTHERS, BAKER'S HILL.

We omit the plate works here altogether, and confine ourselves exclusively to the making of table and spring knives, and razors, for which Messrs. Mappin have deservedly obtained a high reputation. The premises are large and commodious, and in every way adapted for the various branches of business carried on in them.

Nothing but the best Swedish iron, imported direct from the mines, principally from Dannemora, is used here for the manufacture of the blades. The iron is converted in the usual way into steel, which is then double-sheared for table knives, and fused and cast for spring knives and razors. By double-shearing the steel, a better and sharper edge is obtained for table cutlery than cast-steel would give.

The blades are forged from the steel bars in a number of small rooms, containing each a fireplace or hearth, a trough

to hold water, and another trough for the coke, which is specially prepared for its intended use; also an anvil and hammer, and other tools. Two persons are engaged in each room: the one is called the maker or forger, the other the striker. The forger buries the end of the steel bar in the fire to the extent required, and works the bellows to raise the heat to the proper degree. In this operation great care is required, as overheating, or, as it is technically termed, "burning" the steel, will render it totally unfit for cutlery purposes. On the other hand, the heating must be carried sufficiently far to give the metal the proper degree of softness for the subsequent operation of shaping the cutting part of the blade from it. When the end of the bar has thus been duly heated, it is brought to the anvil, where it is fashioned by the striker with very few strokes into a blade of the required shape. This is cut off the bar, which is then again heated for a renewal of the process. The cutting part of the blade, thus rudely formed, is welded to a piece of iron which forms the shoulder or *bolster* (the part rising round the edge of the handle of the knife). To make the bolster of the size and shape required, and to give it neatness and finish, it is introduced into a die by the side of the anvil, and a swage placed upon it, to which a few smart blows in the desired direction are given by the striker. [illegible] and swage are called *prints* by the wor[illegible]e. Besides the bolster, the part which fastens into the handle, technically termed the *tang*, is also shaped from the piece of iron welded on to the cutting part of the blade. After the bolster and tang have been properly finished, the blade is heated again, and then well hammered on the anvil. This operation, which is termed *smithing*, requires particular care and attention, as our courteous conductor informed us. It is intended to consolidate the steel, and to render it brighter. The next process the blade has to undergo is that of *marking*. This is done with a broad punch made of the very best and hardest steel, and having the name and corporate or trade mark of the firm carved on the bottom end or point. The blade is heated to a dull red (*worm-red*, as it is termed by the workmen), and the mark cut in on one side of the blade with the punch by a single blow of the hammer. The mere name of the firm would be no great protection against that most detestable system of piracy which is unfortunately but too often pursued even in this

country; but the corporate mark granted by the Cutlers' Company (the Sun is Messrs. Mappin's well-known trade mark, granted to them in 1810) affords effective protection against piracy by *English* houses, as the penalties attached to the offence are rather too heavy to be lightly incurred. Of course, even this cannot altogether prevent base imitations on the part of Continental and American knaves, who foist their worthless rubbish upon the public abroad by forging the name and trade mark, and imitating the labels and packages of eminent Sheffield firms, like Messrs. Mappin, Rodgers, Wostenholm, and many others.

Now comes the most important process of all, viz., the hardening and tempering of the blades. Upon the effectual performance of these operations depends the practical value of the articles. The Sheffield workmen have justly and deservedly acquired the very highest reputation for peculiar skill in this most difficult department of the cutlery business. The hardening of the blade is effected by heating it to bright redness, then plunging it perpendicularly into cold water, which operation renders it extremely hard, but at the same time very brittle, which is an inconvenience, of course, requiring to be remedied. This is done by the process of tempering. To this end, the hardened blades are first rubbed with finely-powdered sand, to remove scales, &c. from the surface; they are then placed on an oblong tray made of steel, and on this exposed to the fire until they acquire a bright blue tint. The workman judges of the proper degree of tempering entirely by the colour; and the utmost attention is bestowed upon this point, to ensure the most perfect uniformity in this respect. The hardened and tempered blades are then submitted to the manager's inspection, who applies various tests to them, and rejects any that may turn out imperfect in any one point.

We now follow the blades that have been examined and passed by the manager to the grinding mill, or, as it is technically termed, the *wheel*. Each separate shop in the building in which the grinders work is called a *hull*. The grinding is done on stones of various qualities and sizes, according to the kind of articles to be ground. The rough grit stones come mostly from Wickersley, near Rotherham; the finer and smoother grained stones, and the so-called "whitning" stones, come mostly from the more immediate neighbourhood of Sheffield. The blades of table-knives are

ground on wet stones, the grinding stone being suspended, to that end, in an iron trough filled with water to a sufficient height to make the surface of the fluid just touch the face of the stone. The grinding stones, as well as the glazers and polishers, are turned by machinery worked by steam power. A flat stick is used by the grinder to keep the blade pressed to the surface of the stone. The ground blades are then glazed, which simply means that a higher degree of lustre and smoothness is given them by grinding on a tool termed a *glazer*. This consists of a wheel made of a number of pieces of wood put together in such a manner that the edge or face always presents the end way of the wood, which is done to preserve the circular shape by preventing contraction of the parts. The grinding face of the wheel is covered with so-called emery cake, which consists of a composition of beeswax, tallow, and emery. The glazing wheels have a diameter of four feet. The tang of the blade is stuck into a temporary handle, to facilitate the operation. The last process to which the blades of table-knives are subjected in the grinding mill is that of polishing: this is done on circular pieces of wood covered with buff leather, with a coat of finer emery (flour emery) composition upon it, which are made to revolve with much less velocity than the grinding stones and the glazers.

The ground blades are again taken to the manager, who applies several very severe tests to them, to try their temper and edge.

We must now pay a short visit to the handle and hafting department. Knife-handles are made of horn, ivory, ebony, silver, German silver, mother-of-pearl, &c. Messrs. Mappin make the ivory handles used for their table-knives, &c., from elephants' tusks, imported direct by the firm. Two sorts of ivory are principally used, the Egyptian and the African: the latter is the more beautiful and transparent of the two, the Egyptian looking more like horn. The tusks are sawn in appropriate lengths, which are then cut by a small circular saw into handles of the required size. The handles are properly filed, and occasionally also carved or fluted in different patterns. A variety of files are used for these purposes, such as flat files, threading files, hollow files, half-round files, &c. The handle is then bored to receive the tang. The bolster of the blade having been properly filed, the tang is inserted into the bore, and fixed in by cement in

the usual way. It is afterwards further secured by a German silver pin passing through the handle and tang.

The silver and German silver handles are stamped in dies. The mother-of-pearl handles are carved or fluted in different patterns.

The knives thus finished by the hafter are now taken once more to the manager, to undergo a final examination preparatory to their removal to the warehouse.

Spoons, ladles, and forks of every pattern and size, are manufactured by Messrs. Mappin, from the best German silver, electro-plated and highly polished. Even the wearing off of the plating will not destroy the fine appearance of these articles, as the German silver underneath is of the very best quality, and of excellent argentine colour.

Having thus disposed of the table-knife department, we will now proceed to the

RAZOR DEPARTMENT.

Messrs. Mappin's razors are made of the very best cast steel, properly tilted, hammered and rolled. The value of this steel is about £60 per ton. There is no difference in the several sorts of razors as regards the quality of the steel, the same material being used for the one-shilling, two-shilling, three-shilling, and much higher priced razors. The forging of razors is performed by a foreman and striker in the same manner as in making the blades of table-knives. The bars or rods, as they come from the tilt and rolling mill, are about half an inch broad, and no thicker than sufficient for the back of the razor. The anvil on which the razor-blades are forged is rounded at the sides: by dexterously working the blade on the rounded edge of the anvil, a concave surface is given to the sides, and the edge part thus made thinner, which saves the grinder a deal of labour. The blade having been cut off the bar, the tang is formed by drawing out the steel. The blade is then properly hardened and tempered. The last and most important process which the razor-blade has to undergo is that of grinding. The difference in the prices of blades, made all of them of the same material, is owing entirely to the circumstance that stones of much smaller diameter are used for grinding the higher priced blades, and much more time and labour are given to the operation than is the case with the cheaper

sorts. Thus, the best kind of razor-blades made by Messrs. Mappin, the so-called three-shilling razors, are ground hollow on stones measuring one and seven-eighths to two inches in diameter. A hollow-ground razor-blade of this kind may be said to be all edge, and will hardly ever require to be ground again. This applies more particularly to Messrs. Mappin's registered lancet-edged razors. A very excellent and serviceable article is produced by grinding on a six-inch diameter stone. The two-shilling razors are ground on seven-inch diameter stones; the common shilling razors, on ten-inch diameter stones. The difference in the labour is very considerable. A grinder will turn out per week from twenty to twenty-four dozen of the common shilling razors, whilst he can manage only about five dozen a week of the better, and only a couple of dozen of the best sort.

The razors ground on a six-inch diameter stone are more suitable for hard, those ground on a two-inch diameter stone for soft beards. The more common sorts are after grinding lapped on the glazer, and the backs glazed and polished. The three-shilling blades are polished first, then drawn over a wood buff. Razor-blades are, in a great measure, ground on dry stones, which unfortunately causes the atoms of stone and steel to fly about freely, to the great injury of the workmen, and imparts to the whole place where the operation is carried on a peculiar brownish-yellow hue. The minute particles of stone and metal flying about are inhaled by the workmen, and, lodging in the lungs, produce asthma, consumption, and other fatal diseases. This most dangerous feature of the dry-grinding business has, however, been very considerably modified of late by the introduction of an apparatus which, in a great measure, protects the grinders from the dust flying from the stones. This apparatus, which we saw at work at Messrs. Mappin's establishment, consists of a fan on the principle of a winnowing machine, with a flue to take away the dust from each of the stones in the room. The fan is worked, of course, by steam power.

The difference in the price between the three-shilling and the dearer razors is simply in the handles with which they are fitted, the blades being exactly the same in every respect. There are horn handles, ebony handles, plain and carved ivory handles, silver and German silver handles, mother-of-pearl handles, &c. Some idea of the importance and extent

of this branch of the cutlery business may be conceived from the fact that Messrs. Mappin make some 1500 different patterns of razors.

There still remains now to visit one of the most important and most interesting departments of the Sheffield cutlery business, viz., that of the manufacture of

SPRING KNIVES,

or knives that shut with a spring, to go in the pocket. The blades of spring knives are made of the best cast steel only. The ingot of steel, rolled to the required size, is placed in the hands of the forger or *blade-maker*, to be fashioned by him and the striker much in the same way as a table-knife blade, only that the tang or joint part is cut off the steel bar along with the blade, instead of being made of iron welded on to the steel. Penknife blades are generally forged by a single hand, with a light hammer not exceeding three and a half pounds. The breadth of the striking part of the hammer does not exceed an inch, as a broader surface would not be suitable for striking so small an object as a penknife blade. In the manufacture of spring knives the success depends in a very great measure upon the judgment and skill of the workman who forms the blade under the hammer. The forged blade cut off the bar is taken first to the grinder for what is technically termed *scorching*, which means simply rough-grinding the tang or joint part. The blade is also *chorled* or nicked in the shoulder, to guard against its cracking in the subsequent operation of hardening. It is then taken to the marker's shop, to be marked in the same way as the blade of a table-knife. The little recess called the nail-hole or nail-mark is notched in, while the blade is still hot, by means of a chisel round on one side and flat on the other. The marked blades are now returned to the forger for the purpose of being hardened and tempered, which is effected much in the same way as with the blades of table-knives, only that the hardening heat is not raised to below a dull red heat, instead of to a bright red heat. In the subsequent process of tempering again all depends upon the judgment of the workman, spring knife blades being tempered variously according to the different purposes which they are intended to subserve. Thus, for instance, a whittling knife is tempered differently from a penknife, &c.

The tempered blades are carefully straightened; they are then returned to the grinder's shop to have the proper edge given them; after which they, together with all the other portions necessary to make up the complete knife, also with bolsters, rivets, pins, &c., for fastening the whole together, are taken to the cutler's fitting department, the most important of all. Here the knife is made up or put together. Our courteous conductor afforded us ample opportunity of witnessing the whole of the processes of making the different parts which constitute a spring knife, and of fitting them together. We saw a double-bladed pocket-knife with neat ivory handle or covering made in our presence from the first forging of the blade and the cutting of the scales to the finish. There is a separate set of parts required for every kind of knife made; and all the parts have the number of the pattern stamped upon them, to facilitate their being properly put together.

First and foremost there is the "spring," which constitutes the back of the knife. This is made of steel. It is cut out by a fly, then properly hardened by heating it to dull redness, and in that condition plunging it into cold water. It is now moistened with oil, which is then allowed to burn off in the fire. When the oil is gone off, the spring is considered to be properly tempered. Elasticity is given to it by filing; it is also filed down to the thickness of the blade for which it is intended, and bent out of the perpendicular, to give the requisite motion for the blade. It is rough-glazed on a leather-faced glazer, coated with glue and emery, and the inside of it is polished with a steel burnisher. The springs used in pocket-knives vary according to the number of blades.

Then there are the outer and inner scales, of which the former constitute the outer covering of the knife, whilst the latter form the small chambers in which the various blades fit. The outer scales are made of pearl, ivory, horn, shell, wood, or some other suitable material; the inner scales, of brass, iron, or German silver. The inner scales are hammered, to make them properly incline to the outer ivory scales. Dutch metal foil is placed between the ivory scale and the metal scale. The benefit of the Dutch metal interposed between the two scales is, that it brings out the colour, and imparts to the ivory the beautiful flush which it shows. The necessary holes are then drilled with a drill

and bow in the scales, and also in the tangs of the blades. A longitudinal section is cut out from the ivory plate by drill and bow for the insertion of a name-plate, which fits exactly into the aperture cut out, and is fastened with pins passing through holes drilled in. The scales are fastened together with German silver pins, and the nail notches are filed in. The spring is then placed with the blade, fitted between the two double scales, and rough-filed level. The fitting and matching throughout require great judgment and nicety on the part of the cutler.

The fitting of the blade and spring is the most delicate part of the whole process, and requires great practical experience and the most careful and skilful manipulation. The blades are fitted in at right angles; they are taken out again and again, and it takes a good deal of filing, &c., to make them fit exactly as required. One of the principal points to be looked to is to make the blade in shutting fall so that it does not come down upon the belly of the spring, as this, of course, would tend to take the edge off at the point of contact.

There are several branches of the cutlery business in which a few weeks' apprenticeship suffices to enable even boys to earn pretty good wages. But in the fitting department it requires an apprenticeship of full seven years to give a young man even a decent knowledge of his business.

On the occasion of our visit to Messrs. Mappin's establishment, we saw a so-called double-box sporting knife in progress of fitting up. There were forty parts to be put together, the knife containing nineteen useful articles, such as a wood-saw, a cock-heel saw, a hollow gouge, a button-hook, a nail-file, a pen-blade, a pocket-blade, a corkscrew, a punch, a gimlet, a sacking-needle and another needle, a lancet, a picker, tweezers, a pair of scissors, and some other articles. All these articles were furnished ready-made to the fitter, with all other necessaries to put them together, yet we were apprised that it would take him *ten days* to finish the knife!

When matters have proceeded so far as above described, the blades and springs are sent back to the grinder, to have the tang and the outside of the springs polished; after which all the parts are fitted together, and the haft is finished. The bolsters are then carefully either squared or rounded by filing, as required. After this, the knife is

buffed on a sand-buff, then finished on a gloss-buff with rotten-stone and oil. The sand buffing removes all the file-marks, and leaves a dead surface; the gloss-buff gives high polish and finish.

The fine grinding was formerly done on dry stones, which, however, was found to overheat and deteriorate the blades. They are now fine-ground on wet stones before lapping. The plain-ground pen-blades are ground hollow on grinding stones, the pocket blades are glazed on emery buffs. The shoulders of the blades are then ground on a lead lap, by which means they are got perfectly sharp and regular. A lead lap will give the very finest shoulder,—finer, indeed, than could be obtained with any other material. The operation is termed "lapping," most likely from the circumstance that lapidaries use a similar contrivance in their business. The blades, cleaned previously from grease by warming before the fire and wiping, are polished on leather and crocus: this is done by boys with very nimble fingers, who earn excellent wages at the work. After this the finished knives are taken to another department, where they are sharpened on Welsh hones. They are then finally cleaned, and sent to the warehouse.

Some notion of the immense extent to which this branch of the cutlery trade has grown at present, may be formed from the fact that Messrs. Mappin manufacture some 12,000 different patterns of spring knives, many of them, moreover, with several variations. The number of hands employed at these works is from 150 to 200. We cannot take our final leave of this most interesting establishment without expressing to the Manager of the Works, to the gentleman who kindly took us round the spring-knife department, to the foremen of the several departments, and, indeed, to every workman with whom we had occasion to converse, our best thanks for the courtesy with which we were received by all of them, and for the obliging readiness shown to give us all desirable information.

LOCKS AND KEYS.

Door-fastenings, in one or other of their various forms,—as the bolt, the hasp, the chain, the bar, the latch, the lock,—have been known from the remotest antiquity. The most ancient lock is the Egyptian or *pin lock*, which can boast an *authenticated* existence of *at least* forty centuries. This lock, which, as well as the key to it, is mostly made of wood, and very rarely only of metal, even when it is applied as a fastening to iron doors, is in general use to the present day in Egypt, Turkey, and some other parts of the East,—and, strange to say, also in the Faroe Islands. The principal of its construction is very simple, but most ingenious. To the outside of the door a staple is fixed, with three, four, five, or six loose wooden or iron pins, fitted into a corresponding number of cells, bored at irregular intervals in the upper part. These pins, which are headed to prevent their falling lower than necessary, drop by their own weight into corresponding holes in the bolt, so as to fasten the door when the bolt is pushed in to its full extent. The key is simply a straight piece of wood, with pegs at one end, corresponding in number and position with the pins in the lock. This key being inserted lengthways through a slot in the bolt, and raised, the pegs at the end of it, corresponding with the vertical holes in the bolt into which the lock-pins have dropped, lift up the latter, and raising them flush with the top side of the bolt, and thus disengaging them, allow the bolt to be moved backward and forward. When the bolt has been drawn back, the key is lowered and drawn out. To lock the bolt again, it need simply be pushed in, when the upper pins will drop down again by their own weight.

The next in antiquity is the *warded lock*, which has also been known for many centuries, and is even to the present day most extensively used in this country, and, indeed, in most parts of the world. Warded locks are mostly made of iron or brass, and are commonly of an oblong quadrangular shape. The principle upon which most of them are constructed is that of a bolt—either shooting out from the lock to catch into some kind of staple or box, or to detain a staple entering a hole in the edge of the lock. This bolt is

acted on by the bitt or flat part of the key, being driven in or out according to the direction in which the key is turned, the shaft of the latter serving as a pivot or axis for the bitt to move around in a circular course. Inside the case are placed fixed wards, or *wheels*, to bar ingress to any instrument intended to act upon the bolt. The bitt of the key has clefts cut into it corresponding to these wards, which thus enable it to pass them, and to act freely upon the bolt: the latter being thus impelled by the key one way, and acted upon by certain springs in another, is locked and unlocked according to the direction in which the key is turned. The warded lock is, however, faulty in principle, as it is always a task of comparative facility to pick it, even with the rudest instrument, provided only it be so contrived as to avoid the wards by passing round them; and all the numerous devices resorted to to add to its security—such as screws, escutcheons, spiral springs, wheel-and-pinion work, alarums, multiple bolts, &c., have failed to attain the desired end—viz., absolute safety. But then we must not lose sight of the fact that "absolute safety" in the matter of locks would certainly appear to be unattainable, as agents *might* be found to overcome even the resistance of the renowned unpickable, drill-proof and gunpowder-proof safety-lock of our own day. For all common purposes, therefore, the warded lock may well be allowed to retain its position.

Another class of locks is the so-called simple *tumbler* or *lever lock*, which has been in use for more than a century. A tumbler is a sort of spring latch, which detains the bolt of the lock, and prevents its motion until the key, by lifting the tumbler out of contact with the bolt, sets the latter free to move. The simple tumbler lock affords, indeed, somewhat greater security than the common warded lock: still it is, after all, only a little less liable to be picked than the latter.

Another principle of lock construction is that of the *puzzle*, *letter*, or *combination lock*, which is extremely simple, though it may at first sight appear rather complicated. The puzzle-lock is generally made in the form of a padlock, which is opened and closed without the use of a key. The chief among the combination locks is the so-called *ring lock*. This consists essentially of two end-pieces, to one of which a shackle is hinged, and a grooved barrel fixed, and of a

spindle with four or more studs or projections on it in a row. This spindle, which fits pretty closely inside the barrel, is screwed into the opposite end-piece of the lock. To unfasten this lock, one of the end-pieces must be drawn out a little, to allow the shackle to be turned on its hinge. Four or more rings fit on the barrel, having each a groove inside, and a small projecting nib outside, put over the grooves. As the spindle, as already stated, fits pretty tight in the barrel, it cannot be drawn out unless the grooves of all the rings lie in the same plane with the groove in the barrel, so as to allow the studs to pass. The rings are riveted to the barrel, the inner edge of the ring-end being bevelled for that purpose; but they are left to revolve freely round the barrel. Over each of them fits an outer ring, which has marked upon it, on the outside, the whole or a certain number of the letters of the alphabet, with a groove on the inside under each letter. These external rings are put on over the inner rings, at any combination of letters that may be required, taking care always that the groove under each particular letter of the combination coincides exactly with the projecting nib on the inner ring. Now, when these letters are brought into a line with certain notches on the ends of the lock, the grooves in the inner rings and the barrel are also in a line, and the spindle may now be readily slid backwards and forwards, as the studs will pass freely along the grooves. The spindle being then thrust in, the end-piece fixed on, and the shackle shut down, the padlock is locked; the outer rings are then moved with the finger, so as to throw the several inner grooves out of a right line, when the interior flanges will now prevent the withdrawal of the spindle, and accordingly the opening of the lock, until the same letters are brought again into a right line with the notches on the ends of the apparatus. The letters on the outer ring are simply intended to enable the owner to remember the particular word or combination which he had adopted in the act of locking.

In the so-called *dial-lock* we find the same principle applied to the locking of doors. A lock of this kind has one or more dials, with a series of letters or figures stamped on them, and to each dial a hand or pointer, connected by a spindle with a wheel inside the lock, having a notch on it which has to be brought to a certain position before the bolt can be moved. To adjust the notch to the proper

position, a nut on the back of the wheel is loosened, and the hand is set at any letter or figure chosen. In the dial-lock, the dial and hands perform the office of the outer rings, the wheels that of the inner rings in the ring-lock.

The letter-padlock has unquestionably this great advantage, that it requires no key or key-hole, and that no other combination than the one adopted in the act of locking will ever succeed in opening the lock. It is, moreover, strong and durable, and not liable to get out of order. Still, the first class of locks mentioned here, the *Egyptian*, can alone be said to contain the true principle of security—viz., that of several independent movable detainers of the motion of the bolt, any one of which will suffice to prevent that motion, and with a key adapted to move the whole of these detainers simultaneously, and to shift them into positions permitting the bolt to be moved. It is upon this same principle of security that most of the ingenious inventions of late years, such as Barron's, Rowntree's, Bramah's, Chubb's, Hobbs's, Newell's, and many other more or less well-known and appreciated safety-locks, are based.

The limited space at our disposal prevents our going more deeply into the subject of the construction of locks, which is, moreover, foreign to the purpose we have here more immediately and particularly in view,—viz., the application of the factory system and of machinery to lock-making.

The principal seat of the manufacture of locks in this country is generally considered to be in Wolverhampton; and there can be no doubt but that that city has been for several centuries, and continues still to the present day, the great lock-market of England, and the place where the better and best qualities of locks are made, Birmingham and London occupying only a very inferior position in this respect. In fact, most of the locks alleged to be productions of the metropolis may safely claim Wolverhampton for their birthplace. However, the latter city has a most formidable competitor, more particularly as regards the common locks, in WILLENHALL, a township of about 17,000 inhabitants, situated three miles from Wolverhampton, on the Lichfield road. The number of master locksmiths in Willenhall is at present about 400, to not many more than 100 in Wolverhampton. At the beginning of the century these proportions were nearly reversed. It must be admitted, however, that many of the master locksmiths of Willenhall employ only

two or three apprentices each, and hardly ever any journeymen. They work, moreover, chiefly for some of the larger manufacturers of the town, and for the factors in Wolverhampton and Birmingham. Still, there are some establishments here for the manufacture of locks and keys, &c., exceeding anything of the kind that Wolverhampton can show. The largest of these establishments, and the most important in every respect, is that of Messrs. John Harper and Co., known as the "Albion Works," which has now been in existence for about seventy-five years, having been originally established by the father of one of the present heads of the firm, and the grandfather of the other.

Besides the manufacture of locks and keys, bars, latches and bolts, Messrs. Harper carry on also a very large business as ironfounders. The premises are, of course, most extensive, several hundred hands being employed in them in various processes and operations. One of the principal branches of Messrs. Harper and Co.'s business is the manufacture of cast-iron locks, which is carried on here on a very large scale. It is to this branch that we intend to devote our particular attention.

The iron used by Messrs. Harper and Co. for the best malleable castings consists chiefly of a mixture of best Spanish pig-iron and best lawn charcoal-iron from Cumberland. Besides these two sorts, Lancashire iron and Staffordshire iron are also used; the latter, however, more especially for wrought-iron articles.

The coke comes partly from Derbyshire, and is partly made on the premises; Messrs. Harper and Co. making their own gas, and using the light coke obtained in the process for *fine* or *pot castings*, which reduces the cost of the gas to almost *nil*.

The pig-iron is broken with a sledge hammer into pieces about three or four inches long, which are then mixed as required for melting in the cupola furnace, or for fine castings in the pot.

The cupola furnace is about thirteen feet high, and three feet wide in the clear. It is lined throughout with a wall of fire-brick, six inches thick. This lining is covered by another, about four inches thick, made of a peculiar, somewhat argillaceous sand (*Gornal*), which stands the action of the fire better than any other kind of sand. This is effected as follows:—A bed of sand is laid at the bottom of

the furnace, slightly sloped towards the discharging mouth; a wooden cylinder of the height of the furnace, and the required diameter, is then set upright in the axis of the cupola, and the sand rammed in hard so as to fill the whole of the space between the cylinder and the fire-brick lining of the furnace. When this has been fully accomplished, the cylinder is taken out again, and the sand-lining trimmed to the proper form. By the action of the fire, this lining is glazed over with a brown, glossy surface. It requires repairing every week; if the glossy surface once breaks, it will not glaze again, and will no longer protect the fire-brick lining. With a careless founder who pays no proper attention to the sand-lining, it occasionally happens that the outer casing of the furnace gets red-hot. When required for use, a few chips of wood are laid upon the bottom, the discharge-hole being left open; and the furnace is then filled to the top with coke, which must be pure and perfectly free from sulphur, &c. The wood at the bottom of the furnace is now set on fire; and as soon as the body of fuel is sufficiently kindled, the fan supplying the air to the blast-pipes is set in action. This fan is worked by steam. We may here observe, *en passant*, that the steam-power used on the premises for working the fan, blowing the fires, and working the extensive machinery in the general shop, amounts altogether to twenty-five horse. A short time after the blast has begun to blow, and when the coke begins to sink in the furnace, alternate charges of coke and pig-iron are thrown in. As has already been stated, two or three different qualities of pig-iron, varying in price from £2 10*s*. to £4 a ton, are used: there is added also a limited quantity of scrap-iron, consisting mostly of the ridges of former castings, and a certain proportion of limestone, to obtain a purer metal with an easier flow. The worst quality of pig-iron is always charged in first. The discharge-hole is closed with a mass of moist sand, which is afterwards pierced with an iron rod when the metal is in full fusion and all is ready for casting. We need hardly state that the heat about the furnace is most intense, and the light perfectly white, and most brilliant and dazzling. The workman who has the charge of the furnace, and who is generally called the *founder*, goes here by the name of the *teaser* (from the French verb *attiser*, to stir or poke). We found him to be a most intelligent man, thoroughly versed

in every branch and detail of his business, and most obliging withal, and eager to afford us every information, for which we tender him here our best thanks, together with our forgiveness for *teasing* us in the most unconscionable, though, of course, quite unconscious manner, by insisting upon our inspecting his white-hot furnace from every conceivable point of view, until we were half roasted and quite blinded. Our feelings on the occasion, however, most likely aided us considerably to a rapid comprehension of certain dark hints about "hot and dry work," dropped by one of the teaser's trusty aids, which we accordingly translated with cheerful alacrity into the last, though not least, of that glorious trio of monosyllables to which England, in our humble opinion, is partly indebted for her greatness—bread, beef, and "*beer*."

The fused metal is received at the discharge-hole in cast-iron pots or ladles, lined with a coat of loam or sand, to prevent the white-hot metal melting the material of the pot, and is thence transferred to the moulds.

For fine malleable iron castings, the metal is melted in the so-called pot-furnace, in the common Stourbridge clay melting-pots.

The moulds are prepared in the casting shops. There are two casting shops here, employing about forty hands. Besides the different parts of locks, latches, &c., an immense variety of other articles are cast here, in malleable and in common iron, and some also in brass, such as clock-keys, railway and bed keys, frames of egg-boilers, ornaments for bedsteads, mane-combs for horses, door-knockers, pulleys for signal-poles on railways, sheeves for axle and signal pulleys, frame-pulleys for window-sashes, bed-casters, trunk-handles, plates for door-chains, studs for cable-chains, ornamental Gothic hinges for church-doors, ornamental castings for legs and arms of lounging-chairs, vermin traps for the Canadian and American markets, &c.

The patterns for the moulds are mostly cut out in wood, then moulded and cast in iron, brass, or bell metal, and properly dressed.

Red Staffordshire loam sand is used for moulds for common castings, best Mansfield sand for fine castings. For articles required to be cast hollow, solid cores are made of open sand by boys, and baked afterwards in an oven, called the *core-oven*, to harden them sufficiently for use.

A couple of rectangular iron frames, without tops or

bottoms, form a case or box, which serves to give the mould the requisite external support. The two halves of the box carry corresponding ears, one set pierced with holes, the other with pegs fitting into them. A detailed description of the manner of forming the moulds, and arranging and adjusting the various patterns upon them, having been given already in the notice of our visit to Messrs. William Tonks and Sons' Brassfoundry at Birmingham, we have simply to state here, in addition, that for certain castings, a mixture of coal dust and rosin is dusted over the pattern mould, which taking fire when the fused metal is poured in, burns, giving a nice colour to the casting. Some of these moulds hold as many as 150 patterns of keys, bolts, links, tumblers, follows, plates, shuts, and other parts of locks; others, 125; others, 75, 60, 45, 40, &c. The articles cast at Messrs. Harper and Co.'s establishment present a most extensive range of varieties in size and weight, from one and a half hundred-weight a single casting, to forty dozen pieces to the pound of common iron; from twenty-eight pounds a single casting, to forty-two dozen pieces to the pound of malleable iron. The large castings are covered over with sand when the metal is run in, to prevent their cracking; it takes about eighteen hours for a large casting to cool.

The castings removed from the mould are brittle, and break like glass, and will not take the file: they have accordingly now still to undergo the process of

ANNEALING.

There are several annealing ovens here for malleable and for common iron. Each of these ovens is about six feet wide by ten feet deep, and five feet high, and holds forty cans of castings, each can containing from seventy to ninety pounds. A mixture of sand and sawdust is put in with the common iron castings in the can, the former to prevent smelting, the latter to give colour to the castings. The malleable iron castings are mixed with a rich red iron ore, by the aid of which the carbon is extracted, and thus the iron becomes soft, and may be hand-filed or drilled. The heat of the annealing oven is carried to a whitish red, both for the malleable and for common iron castings—but not beyond this, as a higher degree of heat would burn and

altogether spoil the castings. The cans are pushed in and taken out with the aid of an instrument stuck under them, which goes by the somewhat appropriate name of the *devil's toasting fork*.

The properly annealed castings, which are now no longer brittle, and take the file like lead, are taken to the BARRELLING SHOP, where they are put into a revolving barrel, or *rumble*, with numerous perforations in it. This barrel revolving with great velocity by the action of steam power, the mutual attrition of the articles inside frees the latter from the sand, &c., adhering to them. After this process of cleaning, the castings are what is technically termed "devilled" in another revolving barrel, into which they are put, together with a little oil and shoemaker's scraps of leather. When the castings come forth again from the barrel after this process, they look almost half polished. They are now taken to the rough warehouse, where they are sorted by young women, girls, and boys, and put into separate holes appropriated to each of the 3000 different sorts and sizes, ready for the men's use in the

GENERAL SHOP,

for fitting and putting together. In this part of the establishment are manufactured also all wrought-iron goods. About sixty men and boys are employed in this shop, besides a number of girls; the latter chiefly in drilling spindles for door-lock furniture, by drilling lathes,—also in making small screws for fastening the brass and mineral furniture to the spindles. The screws are cut off with nippers from screwed wire. Keys are also drilled here, the drills being moved by steam. The locks are fitted and put together with almost inconceivable rapidity. Among the various machines and mechanical contrivances with which this part of the establishment abounds we notice, more particularly, two powerful Nasmyth's steel-hammers, which are used chiefly for stamping parts of door-bolts, hasps and staples, for shell-boxes for Armstrong's shells, and other articles for government and railway purposes; also a large machine for piercing holes through plates, which is very neatly and ingeniously constructed: we saw it at work upon a number of lock, latch, and bolt plates, piercing as many as twenty-four holes of various sizes through a plate at one blow.

The same machine is also made to cut strong bars of iron into pieces, and to slit large sheets of iron into shreds, which are intended for Harper's patent bolt-plates, and are put into proper shape afterwards by the steam-stamp.

Another powerful machine is used to brighten long and thick rods of iron, which are afterwards cut up and made into door-bolts. The iron rod is first put into pickle, then subjected to the action of the machine, upon the wire-drawing principle, which makes it as bright as any smooth-filing could accomplish, with this additional advantage, that it serves to lengthen a rod of about eight feet long from ten to fourteen inches.

We have no opportunity to give more than a mere passing allusion to the many and various processes carried on in this part of Messrs. Harper and Co.'s establishment, such as forging, stamping, pressing, piercing, filing, bobbing, japanning, &c. &c. Still, before concluding our notice of these important and most interesting works, we may be permitted to select from among the immense number and variety of articles for door-fastening purposes made here, a few for more particular mention. There are, for instance, patent rims (on Carpenter's principle), mortice and dead locks, and cast case door-locks, of various ornamental designs, made here, varying in price from 40*s*. per dozen down to 7*s*. 6*d*. per dozen. The latter sort are manufactured principally for the Canadian and United States markets. It is a most remarkable article, and a positive marvel of cheapness; a lock, with staple and key to match, with a pair of Harper and Co.'s patent vitreous mineral furniture, with shifting spindles, and the proper number of screws for fastening, all for the small sum of 7½*d*. Then there is a patent tumbler padlock, exclusively manufactured by Messrs. Harper and Co., which sells in prodigious quantities in the East, and stands unrivalled for cheapness and simplicity, seeing that it can be sold in retail from one penny each! Also, SHARPE'S patent lever latches for park, field and other gates, with plain or ornamented plates; long screw-catches to screw into the gate-post; balance-handles, insuring the fastening of the gate whenever it is closed, and so constructed that the gate cannot be opened by the cattle; brass-knob barrel-bolts, 9 feet long, extremely neat in appearance, and very light, being only three-eighths of an inch in diameter, instead of seven-eighths to one inch, as is

usual. At the time of our visit, a large order of these for China was in course of execution.

Patent wrought-iron barrel-bolts, manufactured from one piece of sheet metal, and without a single rivet, by which means ten times greater strength is secured than the common riveted barrel-bolt possesses. And so we might go on naming a great many more articles than could possibly be remembered by the reader, but there remains only now to take our final leave of this establishment, with our cordial thanks to Mr. Harper for the courtesy and kindness with which he was pleased to receive us, to conduct us over every part of the works, and to afford us all the information we could possibly desire.

CHEMICAL WORKSHOPS.

CHEMICAL WORKSHOPS.

THE GREAT CHEMICAL WORKS OF MESSRS. CHANCE BROTHERS AND CO., AT OLDBURY.

"The Great Chemical Works at Oldbury cover an area of about twenty-four acres," a piece of information which might have given us some reason for dismay, had we not already received the promise of such able guidance as set us entirely at rest as to the order in which our inspection of the place would be accomplished. This promise being confirmed by the morning's post, we set out towards the confines of that mysterious district known as the "Black Country."

Passing the outskirts of Birmingham, where the tall factory chimneys rise at intervals on either side of the railway line, leaving the charming suburb of Edgbaston and the manufactories of Soho and Smethwick, the approach to Oldbury is marked by a heavy pall of smoke which, hanging over the whole tract of the country, shrouds nature in a dun eclipse. Amidst an undefinable labyrinth of pit banks and hillocks, mounds of cinder, craggy masses of clinker, often lighted by a lurid glare into strange and fitful shape, rise the more regular forms of innumerable shafts, kilns, tall, pyramidal blast-furnaces, and strange uncouth machinery. Crowded together amidst this volcanic waste, as though separated for ever from the life of villages and country homesteads, lie the pitbanks, the collieries, the forges, the works for iron and steel and gas, tin and tar, copper, oil, and lead, the soaperies, the distilleries, the potteries, and, as it seems, a hundred others, for supplying the world with material which has become a second nature wrung from the necessities of the first. Here, amidst din

and clangour, rises the hot breath of a thousand forges, the heavy vapour of brick and lime-kilns, the black and choking smoke of mighty fires, all mingling in one great, black, boding cloud which broods immovable above the earth.

Turning from the contemplation of these things, however, we prepare to visit that particular locality within the overshadowed territory to which we have been directed, and, passing from the Bromford station along the course of a brook whose waters were, perhaps, years ago fresh and limpid, come upon a building which at once indicates that we have reached our destination. The neat buildings, bearing somewhat the appearance of a chapel, are, as we are informed by an inscription on the tablet over the door, Chance's Oldbury Schools; and here we learn that the education of the children is secured by a properly qualified master and governesses, having under their charge more than 200 children, whose satisfactory progress has more than once been attested by the Government inspectors. The short time at our disposal will not permit us to stay, however; and, passing along the boundary wall, we become acquainted with one of the most striking objects of the place, in the shape of a bridge which, starting from the works, crosses the road at an elevation of sixty feet and terminates at a huge mound of "waste." We afterwards discover that an enormous piece of timber framework of great strength supports an elevating apparatus, which, by means of water supplied from a powerful steam-engine, raises the waste from the factory yard to the bridge level, whence it is carted away. Arriving at the gatehouse, where we undergo a brief but effective examination by the official there located, we are at once admitted to the interior, and, passing the laboratory, where glass jars and labelled bottles of various colours and sizes, scientific apparatus, and miniature scales, claim only a comprehensive glance, are conducted by Mr. Rayner, who is the manager of the works, to witness the various processes of which his lucid explanations conveyed to us much chemical information.

There was published some time ago a charming little book called 'Fairy Tales of Science,' and its title coming somehow to be connected in our minds with the present visit, may have given rise to the idea that we had suddenly arrived at the outskirts leading to the kingdom of some eminently scientific gnome; for, continuing our journey to the realms of

chemical manufacture, we pass between glittering cliffs which change their hues as we proceed, from pearly white to shimmering sea-green—see masses of green stalactites heaped here and there—stop before the sheen of crystals—walk upon snow-pure sands—gaze, wonderingly, at hillocks of red, and brown, and black, and brilliant colours, amidst which rise two gigantic chimneys and a score of towers. It is in the main road through the works, and amidst the continuous passage of horses and waggons conveying the various materials from the waterside to their fiery destination, that we become conscious of the word "salt," upon which, collecting our somewhat scattered senses, we say, "Indeed!" and, at once becoming prosaic, learn that this article, of which the white cliffs beside us represent some hundreds of tons, is necessary for the manufacture of sulphate of soda. At the base of the great chimney lie the various apparatus for condensing hydrochloric acid; and, crossing the canal which runs through the centre of the works, we see, arranged upon its wharf, row after row of glass and gutta percha carboys ready to be filled with the different acids now in course of manufacture.

This leads us at once to the "burner-houses," where the sulphur and sulphurous ores are burnt for the production of sulphuric acid. They are large and well-ventilated buildings, containing furnaces so constructed as to ensure the proper combustion of the sulphur stone, or pyrites, which is thrown in when the furnace has attained a certain temperature. The result of the combustion is a copious liberation of sulphurous acid gas, which rises and passes with the nitrous gas (introduced by a peculiar arrangement) along flues leading to leaden chambers, where, combined with steam and air, and the oxygen of the nitrous gas, it becomes sulphuric acid, and falls by its own gravity to the bottom of the chamber.

These chambers, of which there are thirteen, occupy a large area in the works, looking like a quadrangle of black, square fortifications, the top of which (for they are built upon high stages of timber) is reached by broad wooden ladders, leading to planked galleries. Each chamber is 160 feet long and of proportionate height and breadth. They are composed entirely of sheet lead, supported externally by a stout timber framework. As we follow our conductor over the leaden roofs whence we look over that portion of the

works, we are unpleasantly conscious that any accidental breach in the leadwork would involve the danger of being dissolved in a short time by a bath which would leave no remains either of the present description or its authors; and, although we are satisfied that everything is carefully inspected, make little objection to proceed with the next operation by which the acid is rectified.

The quantity of diluted sulphuric acid produced by these huge chambers amounts to 350 tons a week, and is drawn off in leaden cisterns and pans, part of it being converted into sulphate of soda and the remainder into rectified acid.

This is produced in a long building, or rather two communicating buildings, against the wall of which a series of glasses, with retort-shaped heads and arms, are fixed in the brickwork of what looks like an enormously extended French cooking-stove. In these the weak sulphuric acid is simmering by means of a fire which is applied to each glass, the boiling process being continued until it is ascertained that the acid has reached its maximum strength. It is now a fluid colourless as water, but of considerably greater specific gravity, and has to be drawn off from the retort by a syphon into the vessel prepared to receive it—generally a glass carboy containing some twelve gallons, and carefully packed by means of a firm bedding of straw into a protecting hamper. Many hundreds of these bottles of acid are sent away every week.

We are informed that the purer sort of sulphuric acid is that produced from the brimstone, the sulphur itself ensuring a finer quality than the combustion of the pyrites. For this manufacture there is a spacious burner-house provided with a long row of smaller burners or ovens. The sulphuric acid consumed at the works is applied to the production of sulphate of soda; for this purpose a large and heavy cast-iron pan is built up with brickwork, with a firegrate carefully set under the bottom. Into the pan, after it has been moderately heated, a quantity of common salt is thrown, upon which the sulphuric acid is poured from a leaden pipe communicating with the chambers; from the decomposition which takes place, the products are sulphate of soda and hydrochloric acid. The latter passes, in the form of gas, into capacious stone flues, and thence into large and lofty stone condensers, which resemble towers with double turrets, and are reached by wooden galleries

in the same way as the chambers. The sulphate of soda after being boiled in the iron pan, is transferred by workmen to the bed of a furnace of similar construction to those known as "reverberatory" furnaces, where it is roasted and finished previous to its removal to the stock-room, afterwards to be converted into carbonate of soda.

To witness this operation, known as the "black ash" process, we are conducted to a series of furnaces, in the front of each of which a certain weight of sulphate is thrown upon the ground, where it is mixed with regular proportions of coal and carbonate of lime. The workman shovels this mixture on to the bed of the furnace, where the operator frequently stirs it with an iron bar, until decomposition takes place, the sulphate of soda being converted into carbonate, while the sulphur leaves the soda to combine with the calcium of the lime. The charge is then withdrawn, and after a time run into large moulds previous to being "lixiviated"—a process effected by placing some hundreds of the balls made in the moulds in large iron vats, in which water is freely poured upon them for the purpose of dissolving the carbonate of soda, which runs into reservoirs provided for its reception, while the insoluble portion of the substance remains in the vat. We have seen in these processes how the strong affinity subsisting between chlorine and sodium, the constituents of common salt, was unceremoniously set aside by the introduction of that most energetic agent, sulphuric acid—how, in strict poetical justice, this agent of dissention, sulphuric acid, is compelled by the lime of the carbonate to yield its soda to the gentle influence of the carbonic acid; and, finally, how, in the manner of the inevitable marriage at the end of the performance, the carbonic acid combines with the soda, and lives happily as carbonate of soda in solution. This solution has still to undergo several processes of refinement into brown soda ash and white ash until it is sufficiently pure for the crystal-house, to which we are invited to witness its ultimate conversion into carbonate of soda, the "soda" of domestic use. A vast building is devoted to between 200 and 300 great iron pans and vessels of various sizes containing the solution of carbonate in various stages of crystallization, which is assisted by bars placed so as to gather the crystals, which are perfectly white and of a beautiful character; those forming round the sides of the vessels being of con-

siderable thickness, while the pendent crystals are of the oblique, prismatic order, and perfectly defined. The workshop in which this beautiful process is conducted, yields a supply of more than 150 tons of soda a week; hearing which, we discover the origin of the glittering white cliffs through which we so lately passed in the stocking-rooms, and recognise them as being composed of the completed material waiting to be broken and packed in various-sized casks ready for the market.

We have yet, however, to witness the conversion of the carbonate into bicarbonate of soda; known (by again dropping the prefix) as the "carbonate," and asked for under that name at the chemists' shops. To produce this, the crystals of carbonate are methodically placed, many tons at a time, in large vessels, into which carbonic acid gas is forced. When the bicarbonate is formed it is taken out, and dried in hot-air stoves made in compartments which resemble the berths of a ship. From these it is carried to the mills, where it is finely ground, and is now ready for packing, an operation performed in a large warehouse, where the fine dust flies like flour, and, if the blooming complexions and vigorous forms of the girls engaged in the work be any indication, is unquestionably beneficial to health. Crystals of soda are also an ingredient in washing powders, the manufacture of which, upon a large scale, affords employment to a considerable number of females, some of whom are widows and orphans connected with the workpeople of the establishment.

The next important operation being the manufacture of salts of ammonia, we visit the workshop where, in boiler-shaped vessels of iron, the gas-water (ammonia liquor) obtained from the distillation of coal in the manufacture of gas in close retorts is subjected to heat. By this means the ammonia is volatilized, and passing through large worms, condenses, and is received in a suitable cistern. It is subsequently treated with hydrochloric acid until the point of neutralization is attained. We follow this solution to a large brick building, where a number of hemispherical iron pans are placed, each over its own fire. In these the solution is kept boiling until, by the continued evaporation, it has reached the crystallizing point. It is then run off into coolers, where it ultimately forms into crystals of the crude salt, and is heaped in a stockroom into another

row of those cliffs through which we passed to our inquiries. This crude salt is afterwards refined by various processes, the most important of which is sublimation. To effect this it has again to undergo the ordeal of fire. After being slowly dried it is placed in peculiarly constructed iron vessels, each covered with a cast-iron dome. On the application of the fire, the salt volatilizes and rises into this domelike cover, where an effect analogous to condensation takes place, the sublimed or volatilized ammonia gradually encrusting the dome with crystals of sal ammoniac. The covers are now taken off, and the cake of crystal removed and broken up ready for packing. This substance, besides being extensively used by galvanizers, tin-plate manufacturers, and in chemical processes where its great purity renders it valuable, is largely exported to Russia, where it is eaten as a luxurious substitute for common salt.

Much as we are interested by these explanations, it must be acknowledged that the attention of one of our party is distracted by the reveries borne upon the wafts of a powerful odour which penetrates the entire workshop. He afterwards said that it was associated with dreamy recollections of a quiet village church on a sultry summer's evening, with a sleepy humming in the air, a monotonous drawling of a dull sermon, and of a little boy in a confused state of unrest, who, suddenly falling forward on the book board, is caught by protecting arms and awakened by a smelling-bottle. It may seem singular that these reminiscences should have been evoked at such a moment. The explanation will be easy to anybody who reflects upon the subtle influence of certain well-remembered scents in recalling past scenes with which they have always been mentally associated. Adjoining the subliming house, in which we stand, are the buildings for the production of carbonate of ammonia (smelling salts), and this pungent gas volatilizes from the crude and finished salts at a very low temperature, and in quantities particularly undesirable to the manufacturers. To produce this powerful scent, muriate of ammonia is mingled with carbonate of lime, and, the mixture being thrown into retorts, both volatilization and sublimation result. The carbonate passes away and is carefully collected. The first volatilization, however, is not considered sufficient, and the product of the first sublimation is placed in spherical iron pots to be once more sublimed into leaden domelike covers.

From these the carbonate is occasionally removed and broken into pieces. There are rows of these covered pots which furnish a very considerable amount of carbonate of ammonia every week. The vast number of casks and packages required for the weekly supply of these various products, renders it necessary for Messrs. Chance to employ not only a large cooperage, but a sawmill on the works. Outside the latter stands a gigantic stack of timber, while inside the powerful steam-engine, bright and clean as a working model, and the various vertical and circular saws, attest the immense extent of the business.

As we pass onwards, we are invited to look more closely at the beautiful greenish-blue prismatic crystals which had at first arrested our attention, and learn that they are formed of sulphate of iron, and produced in great quantities by the oxidation of bisulphuret of iron, a process which takes place spontaneously from exposure to the air. The solution of the resulting salt, when concentrated and crystallized, becomes an article of large consumption, known as copperas.

Passing the carpenters', smiths', and plumbers' shops, and staying for a moment to glance at the great busy cooperage, we again cross the canal bridge—near which bargefuls of ammoniacal liquor are being emptied into receivers leading to the tanks—leave the boat-building yard, the great heaps of ammonia, and the blocks of leaden chambers, and enter an immense and lofty building known as the superphosphate house. On each side of the factory lie hills of superphosphate of lime, while the centre is occupied by row after row of bags filled with this valuable manure. Numbers of men are employed in mixing the superphosphate with ammonia, nitrate of soda, and other important constituents, while others are filling, weighing, marking, and sewing up the bags ready for the canal boat which lies alongside almost at the door.

Superphosphate of lime is the most valuable ingredient of artificial manure, and is made from bones, or bone ashes, and coprolites. These are treated with sulphuric acid, which, combined with the lime present in the carbonates and phosphates, renders the previously insoluble salts soluble. Thus prepared, the superphosphate is mixed with nitrogenous materials and sent to the farmer. As some indication of the extent of this branch of manufacture, we

learn that during one year, and in the county of Dorset alone, upwards of £50,000 was spent on artificial manures. We have thus briefly witnessed most of the principal operations carried on at these works, resulting in the production of enormous quantities of chemicals used by manufacturers and for domestic purposes, and such as are daily supplied to the various home and foreign markets. These include sulphate of soda; soda crystals, or washing soda; soda-ash of various strengths, caustic alkali, bicarbonate of soda, rectified sulphuric acid (concentrated oil of vitriol), brown sulphuric acid, sal ammoniac, white crystallized muriate of ammonia, sulphate of ammonia, carbonate of ammonia, copperas, washing powder, superphosphate of lime, and artificial manure. In the production of all these articles Messrs. Chance adopt the most scientific processes, and, using a high class of material, obtain chemicals of so uniform a purity that their name has become a guarantee of good quality.

It is now time, however, that we should conclude our visit to these marvellous workshops, where, day and night, with the exception of Sundays, these processes are continually carried on by the six hundred hands who are regularly employed there. As we pass once more towards the gate we are rejoiced to learn that, as well as the schools for the children, there is established at Messrs. Chance's works a regularly-qualified surgeon who is paid from a general fund contributed by the workpeople in proportion to the wages earned, and attends personally twice every day, so that ready relief may be obtained in case of sickness.

This information, with five minutes' desultory chat about the present state of affairs in America, which have had a most depressing influence on the trade in chemicals, and greatly affected the demand for the manufactures of Oldbury, leads us once more to the gate, whence we look towards the tall, spanning bridge which connects the huge mountain of "waste" with this city of transformations.

A VISIT TO MESSRS. HOWARD AND SONS' QUININE, BORAX, AND TARTARIC ACID WORKS, STRATFORD.

This business was founded during the latter half of the last century by Luke Howard, Esq., F.R.S., the author of several standard treatises on meteorology and climatology, in conjunction with the well-known Mr. William Allen, and was removed by them to its present locality in 1805. The first-named gentleman is still living, having attained the patriarchal age of ninety-one. He is surrounded by a large number of descendants, who are more or less connected with the firm. Amongst them may be specially mentioned Mr. John Eliot Howard, the distinguished author of the magnificent 'Illustrations of the Nueva Quinologia of Pavon,' and of numerous papers on quinology in various scientific journals; and Mr. S. L. Howard, whose exertions as Chairman of the Class II Committee of the late International Exhibition contributed so largely to the success of the chemical portion of that undertaking.

Messrs. Howard and Sons' factories are situated at Stratford, on a branch of the River Lea, and cover several acres of ground. The number of workmen employed exceeds 200. With the assistance of the firm, they have lately established a literary and scientific institute, to which are attached an excellent reading-room and library.

The principal manufacture with which Messrs. Howards have identified themselves is the preparation on a very extensive scale of the various alkaloids extracted from cinchona bark, first commenced by them in 1824. Some idea of the magnitude of the business carried on in this single branch alone may be gathered from the fact that when in full work more than a ton of bark per day is consumed by them.

There is perhaps no series of products in our Materia Medica which have received so much attention from chemists, pharmacologists, and botanists, as the febrifuge alkaloids and the barks from which they are extracted. In 1826, Van Bergen enumerated no less than 637 distinct publications on the subject, a number which has been

largely added to of late years by Howard, Briquet, Weddell, Karsten, and a host of others of less note. The last addition to the subject is the magnificent work lately published by Mr. J. E. Howard, 'Illustrations of the Nueva Quinologia of Pavon,' which will amply repay an attentive perusal. The inestimable benefits conferred on man by the introduction of the cinchona barks into medicine are too well known, even to the unprofessional reader, to need recapitulation here. As Englishmen, we must be peculiarly sensible of these advantages, when we consider that the whole of our tropical colonies are as it were built on foundations of cinchona bark, and that without these invaluable preparations many districts in which we have established flourishing cities and busy settlements would simply be uninhabited wastes or European graveyards. The enormous demand for quinine has of late years had a most disastrous effect on the supply of bark, the bark merchants of South America having adopted the suicidal method of destroying the trees for the sake of the bark, the inevitable consequence of which will be that this valuable tree will soon become extinct in its natural habitats. To remedy this, several reports have been at various times submitted both to the Home and Indian Governments, by Dr. Royle and others, representing in the strongest manner the necessity of providing against a speedy cinchona famine, by forming plantations of these trees in India. The supineness of the Government at last yielded before the incessant entreaties of various eminent men, and in 1859 an expedition, under the guidance of Mr. C. R. Markham, set out for Peru in quest of cinchona plants and seeds. After undergoing the greatest hardships the efforts of these brave men were crowned with success, and several hundred healthy young plants are now growing in favorable parts of the northern slopes of the Neilgherry Hills, in Southern Hindostan, having been mostly reared from the seeds obtained by the expedition. The latest reports received from Mr. McIvor, the Superintendent of the Cinchona Plantations, inform us that the young trees are in a very flourishing condition and that before many years elapse Neilgherry barks will take a favorable position in our markets. It remains, however, to be seen how far the change of habitat will influence the quinine-producing properties of these trees.

There are so many well-known works published on the

cinchona barks and alkaloids, that we need only remind our readers of one or two facts connected with them, referring them for fuller information to the last edition of Royle's 'Materia Medica.' Peruvian, Countess's, or Jesuit's bark, was first introduced into Spain as a remedial agent about 1640, having cured the Countess of Chinchon, the wife of the Viceroy of Peru, of a dangerous intermittent fever. A few years before, its properties were well-known to the natives of the countries lying at the foot of the Andes, who had bestowed on it the appellation of *quina-quina*, or the bark of barks. Its introduction into England was met with great opposition, from an absurd idea, that having received the patronage of the Jesuits, it must be necessarily a poisonous preparation intended for the wholesale extirpation of all good Protestants, under pretence of curing them of febrile maladies. It made its way, however, in spite of this ridiculous notion, until at the end of the last century it became one of the most popular medicaments for the cure of fever, gout, and rheumatism. An immense impetus was given to its use about the year 1824, when the alkaloids *quinine* and *cinchonine* were first extracted in a state of comparative purity by Pelletier and Caventou, since which period numerous manufactories of these alkaloids have been established in England, France, Germany, and Italy.

We commenced our inspection of Messrs. Howards' works with an examination of an interesting series of barks, consisting of typical specimens of every year's importation, from 1821 to the present time. They are all labelled with name, locality, and per-centage of alkaloids, and form a complete history of the British bark trade for the last thirty-nine years. The bark imported from certain localities is sent over in skin cases, from others in coarse woollen bags. These latter have been made into garments in thousands by the firm, and despatched to our suffering Lancashire operatives. Before being used the bark is sorted, with the greatest care, as the bark merchants are not always sufficiently scrupulous to avoid sending now and then some odd specimens of false bark. It would occupy too much of our space to give every detail connected with the extraction of the alkaloids from the bark. The process may be shortly described as follows:—The crushed bark is exhausted by several boilings with water, acidulated with sulphuric or hydrochloric acid. The several decoctions are mixed and

filtered. When cool, slaked lime is added, until the liquid becomes alkaline and dark in colour. The precipitate formed is collected, drained, pressed, and reduced to powder when dry. It is afterwards digested in rectified spirit and filtered, the spirit being distilled off until the tincture assumes a treacly consistency. Dilute sulphuric acid is now added, and the liquid is again filtered and crystallized; the yellowish sulphate obtained being decolorized by re-solution with animal charcoal and recrystallization. It is finally dried with great care, at a very gentle heat, to avoid the slightest efflorescence. Sulphate of quinine is always more or less contaminated with the sulphates of the other alkaloids existing in the barks, such as quinidine or cinchonine.

From the experience gained by nearly forty years' study of the nature and properties of these alkaloids, Messrs. Howards are enabled to produce sulphate of quinine almost free from impurity. According to Dr. Herapath of Bristol, their sulphate of quinine contains hardly 5 per cent. of the quinidine salt, while ordinary "hospital quinine" often contains ten times that amount. There has, however, always been a demand for cheap quinine substitutes, which has often been supplied by the compounds of uncertain composition known as "hospital quinine," which is a mixture of several of the cinchona alkaloids in varying proportions, and *quinoidine*, which is a resinous, amorphous substance, bearing the same relation to the crystallizable alkaloids that treacle does to sugar. Messrs. Howards have constantly endeavoured to prevent the necessity of employing those uncertain compounds—first, by reducing the cost of working so much as to bring the price of quinine down from one guinea to seven shillings and sixpence, even while the price of the raw material has been rising; and, secondly, by the introduction of pure salts of some of the other alkaloids. They were the first to introduce as an article of commerce the sulphate of quinidine, an alkaloid which rivals in its properties the sulphate of quinine, at a price varying from one half to two thirds that of the latter salt. Such, however, has been the demand for sulphate of quinidine, that the price has risen to nearly that of the dearer compound. At the International Exhibition they exhibited two new salts—the sulphate of cinchonidine and the muriate of cinchonine. The latter salt has since obtained a very extensive sale. It greatly resembles sulphate of quinine, both in external

appearance and in its medicinal properties, while its low price constitutes it the cheapest known febrifuge. According to Dr. Macpherson, the salts of cinchonine have been extensively used in India for the cure of fevers with excellent effect; the directors of the Cinchona Plantations should, therefore, turn their attention to the introduction of the cinchonine-yielding bark trees as well as to those containing quinine. British quinine manufacturers were protected for many years by an import duty of 6*d.* per ounce on manufactured salt, which, considering the greater cheapness of spirits of wine on the Continent, could hardly be called excessive. This was removed in 1860 by Mr. Gladstone, and the English manufactured article was exposed to an unfair competition. Messrs. Howards have nevertheless held their ground, both in the home and foreign markets, not so much by equality of price as by the greater purity and beauty of appearance of their manufactures.

Messrs. Howards have long been celebrated for the superior make and quality of their borax. They have manufactured it at different times from the Thibet tincal, the borate of lime found embedded in the saline deposits of the coast of Peru, and from the boracic acid supplied to them from the Tuscan lagoons worked by Count Lardarel. The latter product, of which they are amongst the largest consumers, is the principal raw material at present used. The mode of manufacture consists in fusing the crude boracic acid with half its weight of soda ash on the floor of a reverberatory furnace; the mixture frits and effervesces, and is constantly stirred; during the operation a quantity of carbonic acid and ammonia escapes, the latter gas being carefully condensed. The frit is then lixiviated in iron boilers, and allowed to rest until the impurities have subsided. The liquid is then drawn off into leaden tanks, and allowed to crystallize very slowly, as the fancy of the market is to admire large crystals. The ammonia which escapes from the reverberatory furnace is condensed and made into liq. ammon. and ammon. bicarb., two products which are highly valued as articles of commerce, on account of their freedom from the poly-ammonias and hydrocarbons always found in the ammoniacal compounds obtained from gas liquor.

The manufacture of tartaric acid and Rochelle salt is also carried on on a very large scale. The raw material in this

instance is the argols or crude tartar obtained from the various European wine districts. A few samples of tartar have lately been imported from the new wine-growing districts of South America, and it promises to become a valuable article of commerce. Crude tartar is an impure bitartrate of potash. In order to prepare the pure acid, the rough tartar is dissolved in water, and chalk is added in equivalent proportions until tartrate of lime is precipitated, neutral tartrate of potash remaining dissolved. The tartrate of potash in solution is decomposed by chloride of calcium, thus the whole of the tartaric acid is separated as tartrate of lime. The product of the double operation is digested with dilute sulphuric acid, sulphate of lime being precipitated and tartaric acid set free. The clear cold solution is then evaporated, crystallized, and recrystallized, great care being taken to avoid the slightest traces of sulphuric acid. Rochelle salt, the double tartrate of potash and soda, is made by combining an equivalent of carbonate of soda with the purified bitartrate of potash, and crystallizing.

Citric and benzoic acids are also largely manufactured by Messrs. Howards. The benzoic acid is the finest we ever saw, the commercial quality being sent out in laminar crystals, one and a half and two inches in length. The manufacture of camphor is interesting. The crude material is placed in large globular flasks, furnished with a short wide neck; heat is applied by means of a sand-bath, and as soon as the camphor melts, a portion of lime is added, and each flask is covered with a globular receiver, in which the sublimed camphor gradually condenses in the form so well known in commerce. A curious chemical difficulty lately arose during the manufacture of camphor from a certain cargo of raw material. The camphor no sooner began to sublime, than the whole factory became filled with a most unsupportable stench, which put even the workmen to flight. The cause was long sought for in vain; portions of the crude material were analysed without giving any clue. At last a workman picked up a piece of the crude camphor, to which were sticking some very perceptible portions of sulphur. The whole mystery was thus solved at once. The barge which had been used for the conveyance of the camphor had been employed for sulphur, and thus one of the many evil-smelling compounds of that element with organic

matter was produced as soon as heat was applied to the mixture.

The bicarbonate of soda is here manufactured with the greatest care. The ordinary method consists in passing carbonic acid gas over soda crystals and powdering the resulting compound, which is a mixture of bicarbonate and carbonate of soda. The pure bicarbonate has, of course, a much less caustic taste than this compound. Its purity is insured by taking only the outer portions of the carbonated crystals, or "birds' nests," as they are technically termed, and by drying the crushed salt in a very ingeniously-contrived chamber, in which a gently-heated current of air is made to circulate over trays containing thin layers of the salt.

Pure bicarbonate of potash is also prepared by Messrs. Howards with especial care. There is a cheap make of this material offered for sale, which is contaminated with carbonate of lead, from being evaporated in leaden vessels, the presence of this deleterious salt not betraying its presence to the eye. In this factory the whole of the vessels employed are non-metallic, so as to secure its suitableness for medicinal purposes.

The mercurial preparations of this house have also long been famous. The calomel is prepared in a peculiar manner by sublimation with water. By this means is secured the total absence of any admixture of corrosive sublimate, so embarrassing in its effects to the unfortunate patient to whom calomel containing this impurity has been administered.

As a curious instance of the increase which has taken place of late years in the amount of ether used through the introduction of this compound with photography, we may state that a few years ago Messrs. Howards made only a few gallons of ether weekly, while at the present time their annual production is not less than fifteen tons.

The manufacture, too, of the bicarbonate of soda is another instance of wonderfully increased rate of production. At one time this firm were almost the only makers of this article, the whole make of the country being not more than half a ton a week; now it is made in the North of England in thousands of tons annually. Tartaric acid, also, may be cited as another instance of this advance, the productions of this one factory alone being four or five times the amount made in all England in 1820.

The scale preparations made by Messrs. Howards are all warranted to contain certain proportions of the most active ingredients; thus the citrate of iron and quinine prepared by this house is guaranteed to contain exactly 25 per cent. of the citrate of quinine. The practice of making such preparations of standard strength cannot be too strongly commended, as the proportions of the most active portion of these elegant medicaments is found to vary within the most extravagant limits in different samples.

We might go on describing the manufacture of fifty different articles in daily use in pharmacy as manufactured by Messrs. Howards, and give interesting details of a hundred ingenious contrivances practised by them to insure perfect purity in even the commonest materials used in medicine; but as only a limited amount of space can be placed at our disposal, we must most reluctantly terminate our visit, first passing through a well-appointed laboratory, in which we find every possible appliance for analysing samples of the different manufactured products of the works. This little chamber gives us at once the key to the secret of the continuous growth in eminence and importance of the firm whose works we are describing. Founded by two men of high scientific attainments, they were amongst the first of our chemical manufacturers who recognised the value of conducting a scientific manufacture on scientific principles; and the scale upon which the business is now carried on, and the position that their productions occupy in the markets of the world, are standing proofs of the truth of the doctrine that theory and practice must always go hand in hand in manufactures.

A VISIT TO MESSRS. DAVY AND MACMURDO'S CHEMICAL WORKS AT BERMONDSEY AND UPPER THAMES STREET.

THE old-established firm of Davy, Macmurdo, and Co., was first founded in Horney Lane, Bermondsey, about eighty years since. At the beginning of their existence they were amongst the chief makers of the grosser chemicals in the neighbourhood of London; but as the great factories of the North of England became their successful competitors,

owing to their having their raw materials close at hand, the firm gradually confined their operations to the manufacture of those products in which unremitting care and philosophical exactitude were principally required. At Bermondsey, consequently, large chemicals, such as oxalic acid, tartaric acid, alum, potash, and soda, have gradually given way before mercurials, chemicals used in photography, the pure mineral acids, pure ammonia, and a number of other products used in pharmacy and the arts, whose value depends chiefly on their perfect freedom from accidental contaminations. The factory at Upper Thames Street is used principally for those still finer chemicals which require the constant supervision of managers of high scientific attainments, as well as for galenical preparations, and other products which do not necessitate a large amount of space for their manufacture, and do not bring on the heads of the proprietors periodical indictments from neighbours who fail to appreciate the wholesomeness of the fumes of nitrous or sulphurous acid.

THE BERMONDSEY PREMISES.

These are situated in Horney Lane, Bermondsey, and cover a large extent of ground. We were conducted over them by Mr. Yates, one of the partners in the firm; and we take this opportunity of thanking that gentleman for the courteous manner in which he acted as our *cicerone* during our several visits to both establishments. The most important products made at Bermondsey are undoubtedly the various

MERCURIAL PREPARATIONS.

Certain preparations of mercury were used in medicine as far back as the thirteenth century. The writings of Theodorick, a monk of that era, contain cautions against taking cold while under their influence. Joseph Almenar, a Spanish physician, recommends them in a work bearing date 1516; and Phrisius gives different formulæ for the preparation of mercurial ointments to be used in venereal disorders. The great Paracelsus, however, was the first writer of any eminence who showed that mercury might be administered internally with safety and advantage. Since his time its use in medicine, under one form or another, has

gradually increased, although many men of great renown have at various times declaimed against it in the strongest possible manner. The great increase in the consumption of mercurial agents has rendered their manufacture one of the most important in the whole range of chemical products. The immense efficacy attending the exhibition of mercury in numberless diseases is too well known to our readers to need recapitulation; they may, however, require to be told that the principal mercurial compounds used in pharmacy are red and white precipitate, calomel, and corrosive sublimate. The manufacture of red precipitate—or nitric oxide, as it is often improperly called—is comparatively simple. Metallic mercury is dissolved in dilute nitric acid with the aid of heat, and the resulting solution evaporated to dryness. The nitrate of mercury thus obtained is placed in iron pans to the depth of an inch or an inch and a half, and exposed to heat until the whole of the nitric acid is dissipated. Although apparently a simple process, a good deal of care is necessary in the application of the heat in order to obtain a crystalline compound, that form being much valued in the market. White precipitate is made by throwing down a mixture of chloride of mercury and mercuramide, by adding liquor ammoniæ to a solution of corrosive sublimate. The manufacture of calomel is attended with somewhat greater difficulty. The first step in the process is the formation of persulphate of mercury, by dissolving the metal in oil of vitriol. A mixture of the persulphate, metallic mercury, and chloride of sodium, is then made and sublimed in an earthenware retort. The resulting calomel generally contains a small portion of metallic mercury, which is got rid of by a second sublimation into a large chamber, on the walls and floor of which the pure calomel sublimes in the form of a brilliant white powder. It is afterwards washed with warm water, in order to remove any trace of corrosive sublimate that may be accidentally formed. The sublimed calomel taken from the chambers of Messrs. Davy and Macmurdo's factory is so free from the higher chloride, that the water used in washing it is hardly darkened on the addition of a solution of hydrosulphuric acid. In making the chloride—or bichloride, as it is frequently improperly called—the precipitate is mixed with common salt only. The mixture is placed in an earthenware retort, with a hemispherical head of the same material. Heat is carefully applied below

the iron jacket with which the retort is surrounded, and a mutual interchange of bases takes place—the sulphuric acid and oxygen going to the sodium to form sulphate of soda, and the chlorine seizing the mercury and subliming as chloride of mercury in the upper part of the retort, in the well-known hemispherical form. The other preparations of mercury used in chemistry and pharmacy are made principally at the establishment in Upper Thames Street.

CYANIDE OF POTASSIUM.

This important salt, so largely consumed in electrotypy and photography, is made in large quantities by Messrs. Davy and Macmurdo. An intimate mixture is made of eight parts of the yellow ferrocyanide of potassium and three of dry carbonate of potash, to which a small portion of powdered charcoal is added, to prevent the formation of cyanate of potash. The mixed mass is heated in a covered iron pot until it has ceased to give off bubbles of carbonic acid. The iron separates and falls to the bottom of the fused salt: the charcoal, however, remains diffused. Subsequent solution, filtration, evaporation to dryness, and fusion yields a milk-white product almost chemically pure. For photographic purposes Messrs. Davy are about to adopt a suggestion made to them by an old photographer. Cyanide of potassium, as supplied in the lump, is exceedingly annoying to weigh. In breaking it up pieces generally fly about, leaving their mark wherever they alight: the notion, therefore, of casting the salt in sticks of a certain weight, is an excellent one, and will be readily appreciated by both amateurs and professionals.

THE PURE MINERAL ACIDS AND AMMONIA.

These important products have engaged the attention of Messrs. Davy and Macmurdo for many years past. By using nitrate of potash, or soda, free from contaminating chlorides, nitric acid of 1·500 specific gravity is obtained, perfectly free from chlorine, that very frequent accompaniment of so-called pure nitric acid. In like manner, by using similar pure materials, hydrochloric acid of great purity, and free from colour, is made in large quantities. Liquor ammoniæ of great purity is manufactured from good

commercial chloride of ammonium. The compound obtained is thus rendered perfectly free from those coal-tar abominations existing in ammonical compounds derived from gas liquor, which are so perplexing both to the scientific chemist and to the practical pharmacist. Passing upstairs, and somewhat reluctantly compelled to leave undescribed the making of a dozen interesting preparations, we come to the upper floor of the building, where most of the wet processes are being carried on. Messrs. Davy have paid much attention to the manufacture of the double sulphate of ammonia and iron, first recommended for use as a development agent by Mr. W. Crookes in the pages of the 'Photographic News.' Although disapproving of the use of iron developers as a general rule, we must yet concede that very excellent results may be obtained with the new compound. It crystallizes in pale apple-green masses, readily soluble in water. Twenty-five grains to the ounce of water, with forty drops of Beaufoy's acetic acid and a few drops of alcohol, form a first-rate developer in cold weather. Looking round, we find numberless processes going on which engage our interest and attention: want of space obliges us only to mention a few of them. In a large leaden trough in one corner of the room is a mass of iron turnings simmering in a solution containing citric acid in excess. When the iron is dissolved the liquor is filtered, and liquor ammoniæ is added until the neutrality is reached. The solution is then evaporated down in large pans until it has reached a certain degree of concentration, after which it is allowed to cool, and sent to Upper Thames Street to be converted into scales. The ammonio-citrate of iron is one of the oldest and most esteemed of the very numerous scale preparations, and is made in large quantities by Messrs. Davy and Macmurdo both for the home and foreign markets. Tungstate of soda is now being manufactured in large quantities for use as an anti-flammable agent in starch. Messrs. Davy have just commenced making a very superior quality of this article. The great difficulty in obtaining pure tungstate of soda arises from the commercial quality containing very appreciable quantities of both sulphate of soda and chloride of sodium, derived from the impure carbonate of soda from which it is made. Messrs. Davy, determined to obtain a pure article, commence by throwing down pure tungstic acid, which, when neutralized with carbonate of soda from the

ordinary impurities, forms tungstate of soda of a quality not often obtained. A little further on, a boy is ladling emerald-like crystals of sulphate of iron from their mother liquors; and our nose soon informs us that a quiet, unassuming, harmless-looking still is silently at work making hydrofluoric acid. An immense demand has lately arisen for this substance by the glass-workers. Embossed and figured glass, which but a few years ago was almost entirely confined to the gin-palace, is rapidly making its way into private dwellings, and Messrs. Davy often find it difficult to keep up the supply. Taking a look at some fine crystals of our old pyrotechnic friends, the nitrates of strontia and baryta, we are glad to leave this floor, the chemical vapour bath in which we find ourselves being far from pleasant. Mr. Yates then shows us a series of ingeniously-contrived drying closets, and we reach the ground-floor once more, to take a second look at some benzoic acid, which was just beginning to sublime at the commencement of our visit. The wet process is adopted for procuring this beautiful product. Powdered gum benzoin is mixed with milk of lime and boiled, the resulting benzoate of lime being mixed with dilute hydrochloric acid. The precipitated acid is then sublimed in large iron pans covered with hoods, on the interior of which the benzoic acid crystallizes in the well-known feathery crystals. There are a large number of other operations going on, which tempt us to linger about the factory; but we remember that we have another establishment in Upper Thames Street to visit, and resisting the charms of alum ustum, prussic acid, and a dozen other substances of great interest, we pass out of the factory in a half-salivated condition.

THE UPPER THAMES STREET ESTABLISHMENT

forms a large block of buildings at the eastern corner of Old Swan Lane running half-way down towards the river Thames. As we have already mentioned, this factory, which also includes warehouses and counting-houses, is, devoted to the production of the finer chemical products used in pharmacy and the arts. Once more under the courteous guidance of Mr. Yates, and this time accompanied by Mr. C. Davy, the head of the firm, to whose valuable exertions on the Exhibition Committee so much is due, we

commence our inspection of the works with the ground-floor. The first things we are shown are the engine, which, like a heart, sends life and motion over the whole establishment; boilers for generating steam; grinding and crushing mills; and a machine for making mercurial ointment. The latter consists of a circular basin to contain the grease and mercury. A revolving fork, with a sixty-pounder round shot running on each prong, triturates the mass most perfectly and expeditiously. The rest of the basement is occupied with packing, bottle-washing, and other operations, with which we have nothing to do; so ascending a flight of stairs, we come to the floor where the fine chemicals are manufactured. It is hardly necessary to state that everything connected with this department is kept in a scrupulously clean condition. All the evaporations are carried on in double pans, the outer one being of iron, and the inner of Cliff's best stoneware. Between the two pans runs a steam-pipe, the heat of which is kept down to about 170° Fah., to avoid the possibility of decomposition from too great a heat in certain salts. Round the rooms are long counters, upon which are crystallizing various fine chemicals; and underneath these are hot-air cupboards for drying precipitates and crystals. We could not possibly attempt to describe the whole of the chemicals manufactured here; it would be simply transcribing the major portion of "Fownes" or "Miller:" suffice it to say that there is hardly a chemical compound to be named which Messrs. Davy do not keep in stock, whether for pharmaceutical, artistic, or purely scientific purposes. The contents of a few of the evaporating basins at work will give a notion of the out-of-the-way substances which Messrs. Davy are obliged to make,—bromide of arsenic, arseniate of quinine, acetate of manganese, chlorate of baryta, oxalate of cerium, and so on. The valerianates of iron, zinc, ammonia, and quinine, are now being used as antispasmodics in rather considerable quantities for such uncommon compounds. Valerianic acid is now made entirely from fusel oil, the quantity obtained from the plant being too small to allow of its being profitably employed. Sulphuric acid and fusel oil are added to a strong solution of bichromate of potash, and distilled; the mixed distillate is saturated with carbonate of soda, and the separating oils are removed. The solution remaining is boiled to drive off all the oil, and is then decomposed by sulphuric acid. The distillate is once more rectified,

and is now considered pure. As our readers know, there are few things on this earth that smell so vilely as valerianic acid and its compounds. Notwithstanding their disagreeable smell and taste, they are greatly esteemed for their curative effects. In a large pan close by, which we are glad to cover up again as quickly as possible, is fermenting a mixture of cheese, sugar, and chalk, for the production of butyric acid and ether, used in the manufacture of artificial fruit essences.

In another part of the laboratory a quantity of pure gold, sufficient for a well-paid curate's yearly stipend, is simmering in aqua regia in a huge evaporating basin, to form chloride of gold for photographic purposes. The chloride of gold supplied by Messrs. Davy and Co. in dry, well-formed crystals, is warranted to contain the exact equivalent of metallic gold. The same may be said of the double chloride of sodium and gold made by them, which is much preferred by some photographers, as it can be weighed with greater ease, being a dry instead of a deliquescent salt. The other staple photographic material, nitrate of silver, is not now manufactured by Messrs. Davy and Co., the profit obtained on this article being so small as to leave the trade entirely in the hands of two of our principal assayers, who may be said to procure their raw material, metallic silver, at a reduced rate. To give our readers a notion of the profits of this branch of trade, we may mention that in one ounce avoirdupois of nirate of silver there is metallic silver of the value of 2*s.* 11*d.*, and that the dry salt is sold at 3*s.* 4*d.* wholesale, leaving exactly 5*d.* per ounce profit to cover loss, nitric acid, labour, interest on plant and capital, &c. It will, therefore, be readily perceived that the temptation to adulteration in both of those articles is very great; so much so that nitrate of silver containing 50 per cent. of nitrate of potash, and chloride of sodium and gold with about 5 per cent. of metallic gold, have been offered in the market. Ascending to the next floor, we find it occupied by numerous percolators, filters, stills, boilers, and pans for the preparation of galvanicals. Messrs. Davy have introduced into the market a quality of sulphuric ether for photographic use made from methylated spirit. *A priori*, there appears to be no reason why a mixture of the oxides of methyl and ethyl (as this ether would undoubtedly be) should not produce as good a collodion as

the pure vinic ether, or oxide of ethyl itself. At first photographers seemed inclined to consider that any mixture of the methylic compounds in their collodion produced fogginess; but it has been most satisfactorily proved that this fogging arose, not from the methylic compound itself, but from certain tarry contaminations from which it was very difficult to purify it. The quality of ether made from methylated spirit by this firm answers perfectly for the most delicate collodion; and considering that it is only half the price of that made from ordinary alcohol, it is worth testing to the very utmost by every practical photographer. The same remarks apply to the absolute alcohol made from the same source. We also examined and tasted samples of sweet spirits of nitre made from both ordinary and methylated spirit, and found both specimens perfectly sweet and pleasant. By rubbing in the hands, a very slight methylic odour was perceptible in that made from methylated spirit; but tasting them together, it was difficult to distinguish between them. We should be wearying our readers and taking up too much space if we were to describe the whole of the galenicals made by Messrs. Davy. The whole are made in stoneware pans, heated by steam at a low pressure. Messrs. Davy are manufacturing glycerin of a very fine quality, almost equal to that made by Price's Patent Candle Company. The crude glycerin is derived from a foreign source, and before purification presents the appearance of rough petroleum. The purified article is as clear as water, is perfectly sweet, and has the same specific gravity as Price's. Large quantities of the new and favorite American remedy, podophyllin, are now being manufactured by Messrs. Davy. It is readily made by exhausting the coarsely-powdered mandrake root with alcohol by percolation, and throwing down the resinoid principle with water. It is then washed, filtered, and dried at a temperature of about 90° F.

Passing up higher, we come to the floor where the three principal oils—almond, cod-liver, and castor oils—are being filtered. The numerous packing-rooms and store-rooms for bottles and general stock give us a good idea of the amount of business got through by this house. Climbing up a breakneck staircase, we come out on the roof, and find it to be one of the most important floors of the building. Here it is that all operations during which gases such as sulphu-

retted hydrogen are evolved are carried on, far away from such delicate preparations as iodide of cadmium, which would soon be blackened and spoiled by even an infinitesimal portion of this compound. The greater part of the roof is, however, occupied by tables, on which are ranged brigades of bottles drawn up in regiments and companies according to their size, and containing almond, cod-liver, and castor oils, which are being gradually bleached by such little sunshine as we are favoured with in London. Thus, every cranny and corner of this large building is utilised,—except, indeed, the chimney-pots; but even they will, no doubt, be put to some use in time by the ingenious managers of the firm. Descending once more to the counting-house, we find a large array of bottles drawn up for our inspection. They contain some twenty different specimens of artificial fruit essences, upon the perfection of which Messrs. Davy and Macmurdo —or, we perhaps ought rather to say, Mr. Routledge, one of the partners in the firm, particularly prides himself. It was at the Exhibition of 1851 that artificial essences first attracted any considerable attention. To speak somewhat generally, they are mixtures of different compounds, derived from valerianic, pelargonic, butyric, amylic, and several other acids and ethers. By judicious mixture in alcohol, artificial essences of nearly every fruit are made, some of which are absolutely perfect in their resemblance to the real fruit essence, while others leave a great deal to the imagination. Most of them are coloured to represent the juice of the fruit from which they are supposed to be derived. As a very little of them goes a long way, cheap fruit-syrups are made with them so easily that we wonder at their not being more generally adopted. Now that many chemists' shops contain a syrup-table for the use of thirsty summer customers, we recommend them to our readers as subjects of experiment. We tasted a great number of them mixed with water and simple syrup, a few drops of weak acetic acid being added to bring out the flavour. We must award prize medals of the first class to the raspberry and ribstone pippin flavour, which are truly astonishing in their similarity to the real fruit. Then would come the black and red currant, the slightly musty flavour of the former fruit being wonderfully imitated; the pine apple and the pear; honorable mention being bestowed on the orange, the blackberry, and a number of others. The raspberry vinegar made from

the essence is perfectly undistinguishable from the true compound. Having thoroughly tested these specimens of his skill, we hesitatingly ask Mr. Routledge for some particulars, but we find that it is impossible for him to give them to us. With sundry bottles of ethereal compounds before him, ranged like the colours in a painter's palette, he adds ounces of one, drops of another, and mere hints of others, until he ultimately finds that he has made the essence required. We might as well ask the artist how he mixes his russets and purple grays, as ask Mr. Routledge how he makes artificial ribstone pippins and raspberry out of ethers whose origin is to be sought for in stinking cheese and the foulest fusel oil.

In taking our leave of the very interesting works of Messrs. Davy, Macmurdo, and Co., we feel that our best thanks are due to the firm generally for giving us every possible assistance and information we could desire; and in particular to Messrs. Davy and Yates, for acting as our guides on several occasions: not forgetting Mr. Routledge, who so pleasantly surprised our palate, and Mr. Mason, the scientific chemist of the firm, who kindly enlightened us on numerous points of a technical nature.

A VISIT TO MESSRS. HUSKISSON AND SONS'.

This is one of the oldest chemical factories in existence in this country, having been founded in the latter half of the seventeenth century by Dr. Samuel Towers, an eminent physician of that age, and the direct lineal ancestor of the present proprietors. This gentleman, who was for those days a very clever practical and theoretical chemist, and an ardent lover of science generally, established a laboratory in Oxford Street, or Oxford Road, as it was then called. He was afterwards joined in business by his brother, George Towers, with whose assistance he carried on the concern most successfully for many years. Previous to this, the apothecaries of that day—the precursors of the present race of chemists and druggists—were accustomed to prepare their chemicals on the leads of their houses; and it was Dr. Samuel Towers who was one of the first to carry out

successfully the notion of establishing on an extensive scale laboratories for the manufacture of chemicals in a greater state of purity and excellence than had hitherto been attained. These laboratories were no sooner in working order than the apothecaries so thoroughly appreciated their productions, that they abandoned the method of private manufacture, and gave up their leads to the more pleasing occupation of gossiping, love-making, and a number of other agreeable pursuits of a similar nature, of which chatty Mr. Secretary Pepys has left us so amusing an account in his famous 'Diary.' Those of our readers who pass up and down the Strand occasionally should look up at the carefully railed-off leads on the roof of Prout's, the chemist, a few doors from Temple Bar, on the south side of the Strand. They were, no doubt, employed for the purposes above named by Mr. Prout's predecessors, the shop having been used as a chemist's for many years past.

The neighbourhood of Oxford Street, in which Messrs. Towers's first manufactory was situated, soon became so fashionable that they were obliged to move out of the way of the exquisites of the day, who would not allow chemical fumes "to come between the wind and their nobility." The establishment was consequently transferred to more convenient and extensive premises at Mount Pleasant, near Cold Bath Fields; and Messrs. Towers gradually enlarged their business until they obtained the patronage of the Government for the chemical requirements of the Royal Laboratories at Woolwich Arsenal and elsewhere. In addition to the Mount Pleasant premises they established other factories in another part of Cold Bath Fields, and in Maiden Lane, Battle Bridge, on a portion of the ground now occupied by the King's Cross Terminus of the Great Northern Railway. The latter premises were specially employed for making liquor ammoniæ, or hartshorn, as it was then called (being solely obtained by the distillation of stags' horns and bones), oxalic acid, and other products too deleterious to manufacture in an increasing neighbourhood without the appliances of the present day for collecting and neutralizing offensive vapours. The last-named substance was manufactured in what was then considered large quantities, one consumer alone taking thirteen hundred-weight weekly, at *7s. 6d.* per lb. Its principal use was for dressing the upper portion of top-boots, so much worn at that period, and with-

out which no gentleman was considered to be properly "dressed." Towards the end of the last century, an unfortunate misunderstanding arose between the Towerses and the Huskissons. Mr. Towers soon after retired from the business, and spent the remainder of a long and useful life in the cultivation of literary and scientific pursuits, editing several scientific periodicals, and contributing greatly to the advance of the science of his day. He may be mentioned as one of the first who turned his attention to the utilization of sewage for manure, and spent large sums of money in experimenting in this direction. He died at Croydon, at a patriarchal age, at the beginning of the present century, deeply regretting the unfortunate differences that had separated him from the firm.

After the dissolution of partnership, the Huskissons purchased a large portion of the Swinton estate, which was then surrounded by farms and fields, and erected premises and laboratories, which are now bounded by Swinton Street, Constitution Row, George Street, and Bagnigge Wells Road. So hemmed in are the premises by houses, and so perfect are the appliances used for carrying off the smoke and fumes inseparable from chemical manufactures, that neither the sight nor the smell would give the passer-by the least suspicion that one of the largest establishments in London existed in the neighbourhood. The site of the present works is interesting from a historical point of view, from being the spot on which the last decisive battle between the Romans and Britons was fought, on the banks of the river Fleet, and which gave the name to the Battle Bridge long since swept away, and existing now only in name. Part of the estate was also covered with the famous cinder-heap which a lucky dust-contractor of the period sold to the Russian Government for a small fortune, for making the bricks used in the rebuilding of the city of Moscow.

From the above particulars it will be seen that this house originated the manufacture of chemicals in their present state of excellence and purity. One of the most striking examples of this is in the manufacture of

POTASSIO-TARTRATE OF SODA, OR ROCHELLE SALT.

This well-known salt was only met with in commerce in impure amorphous crystalline masses, or at best in rude

irregular crystals, until the middle of the last century, when Mr. George Towers became impressed with the notion that it could be produced in clean and regular crystals of uniform composition. He thoroughly devoted himself to the task, and after repeated experiments extending over a period of seven years, he eventually succeeded in producing those beautiful tubular crystals for which this house was so long celebrated. George Towers was a man of strong religious principles; and on completing the process, he was so struck by the crystalline beauty of the masses he had produced, sparkling, as he said, "like an island of jewels," that he fell on his knees beside the crystallizing pans, and returned thanks to the Almighty for the discovery he had made. At that period the crystals were the only form in which Rochelle salt was sold. The crystals were sorted into their different sizes, and sold at prices varying from four to eight guineas per cwt., according to their uniformity. The salt is still manufactured here on a very large scale by the old process of decomposing the double tartrate of potash with carbonate of soda. Amongst other articles for which this house was specially famous, were carbonate of magnesia, calcined magnesia, the aromatic spirit of ammonia, spirit of nitric ether, and many other substances, into the manufacture of which time and space will not permit us to enter. We must not, however, pass over

BICARBONATE OF SODA.

Towards the end of the last century, Samuel Huskisson, the father and grandfather of the members of the present firm, discovered the successful method of making a true bicarbonate of soda by passing a stream of carbonic acid through small crystals of the mono-carbonate.* The carbonic acid used in the process was generated by burning charcoal. This mode of procedure produced an article altogether superior to that made by the then existing method of passing carbonic acid through a solution of the carbonate. The process remained a secret of the house for more than twenty years, the price being 8*s.* 6*d.* per lb.; and many hundredweights were sold weekly. The secret did not long remain so, but was divulged by a relative, and other makers immediately entered into competition with the Huskissons. At that time the source of carbonate of soda

was barilla; and it was remarked that the iron vessels employed in the evaporation of the salt became corroded and spoilt by a black sediment which was deposited during the manufacture of sulphate of soda. The matter, however, was not followed up. Had it been so, England would have had the honour of discovering iodine; for that element, as the reader can no doubt easily guess, was the black deposit that destroyed the iron pots. Although so narrowly missing the discovery of this element, iodine was destined to play a considerable part in the future greatness of the firm of Huskisson and Sons. They still retain the corroded vessels, which are interesting for another reason. In the old days, sulphate of soda, or Glauber's salts, was subject to a duty, and the pans were locked and unlocked by the exciseman when going his daily rounds. It was then a product of considerable importance, being much more used in medicine than it is at present.

CHLOROFORM.

Upon the introduction of this valuable anæsthetic agent, Messrs. Huskisson became large manufacturers, one of the firm being the first to call attention to the supposed formation of hydrochloric acid when the chloroform was agitated with pure sulphuric acid, and also to the appearance of a pinkish colour in the product from the formation of a salt of manganese, owing to the protoxides of that metal being employed in a subsequent part of the process. In one of the early numbers of the 'Annals of Pharmacy,'—a talented, but, alas! too soon defunct literary predecessor of the 'Chemist and Druggist,'—a formula was published by a member of the firm, which was afterwards, and is, we believe, still adopted by the majority of manufacturers of chloroform. Although large makers at first, Messrs. Huskissons gradually restricted this manufacture within narrow limits; their efforts to increase their production being paralysed by the disparity between the duty on English spirits and Scotch whisky, which was so great as to throw the trade almost exclusively into the hands of our Scotch neighbours.

On all sides we find processes going on which it is impossible to describe, which may, however, engage our attention in the future when visiting the works of other makers.

We must, however, give a glance at some pure bicarbonate of ammonia which is being re-sublimed at a very low temperature in milk-white masses. In another portion of the premises, pure carbonate of potash is crystallizing in large vats. Considerable quantities of the pure salt are now manufactured, being much employed in making cyanide of potassium, certain varieties of glues, and other processes where the precise per-centage of potash is required. In other vats, pure nitrate of potash is shooting forth its familiar hexagonal prisms in radiating masses of great beauty. Apropos of nitrate of potash, a curious fact may be mentioned, showing how a scientific manufacturer made some thousands of pounds by the application of a little chemical knowledge to an ordinary commercial transaction. In 1794, a large fire occurred at the East India Company's saltpetre warehouses at Ratcliffe Highway, destroying 600 houses and stores, worth over one million of money. The Huskissons, on speculation, offered 5*s.* per cart-load for the *débris* of the portions of the premises in which some 40,000 bags of saltpetre had been stored. The salvors ridiculed the notion, and pitied the firm for embarking in what appeared to be so wild a speculation. Their ridicule was, however, turned into mortification mingled with admiration when they found that Messrs. Huskissons, on washing the rubbish, had succeeded in extracting an amount of carbonate and nitrate of potash which, when sold, brought them in a clear profit of several thousands of pounds.

We now come to the products which are the specialities of the house—the iodine and bromine preparations.

IODINE AND BROMINE.

The chemical and physical properties of iodine are, doubtless, well-known to our readers. It may, however, be as well to remind them that iodine is an elementary body, crystallizing in bluish-black scales, with a metallic lustre, fusing at 225°, boiling at 347°, and evaporating at ordinary temperatures, especially when damp. Its odour is similar to that of chlorine, and it sublimes in violet-coloured vapours. Its history is interesting; the circumstances of its discovery showing what immense practical service manufacturers may render to science by intelligently followed up unexplained facts that may come under their notice when

working with large quantities of material. Iodine was discovered by M. Courtois, a French manufacturer of saltpetre, residing at Paris, who, on adding sulphuric acid to mother-liquors of sea-water, from which nearly all the sea-salt had been crystallized, in order to transform any remaining traces of carbonate of soda into sulphate, noticed that a beautiful violet vapour arose from the mixture as soon as heat was applied. At the same time, he was struck with the very rapid manner in which the iron vessels he had used became corroded and destroyed. On carefully examining the residues in the boilers, he obtained a peculiar substance, crystallized in iron-gray plates, having a metallic appearance. This crystalline material, on being submitted to the action of heat, gave forth the violet vapour he had at first obtained. Although a man of great sagacity and high scientific attainments, M. Courtois hardly felt himself strong enough to pursue his investigations into the properties of this new substance, which he rightly conceived to be an element. He accordingly communicated his discovery to M. Clement, an eminent chemist of the day, who at once set about investigating the nature of the new body; and a few weeks after, the celebrated Gay-Lussac read a paper before the French Academy of Sciences, in which he demonstrated that the new substance was an element similar to chlorine, and gave an account of its most interesting properties. Some days after, Sir Humphrey Davy, who happened to be in Paris at the time, read another paper on the new element before the same august body, agreeing in the conclusions arrived at by his eminent colleague, and showing the important bearing that this discovery had on his theory of the elementary nature of chlorine, which he was then engaged in working out. It was not, however, until 1819, some six years after its discovery, that iodine was first employed in pharmacy. The merit of the introduction of this powerful curative agent into medicine is due to Dr. Coindet, a physician of Geneva, who in that year commenced a series of experiments upon it as a remedy for bronchocele or goitre, a malady unfortunately only too common in the mountainous districts of Switzerland. Dr. Coindet was first prompted to try iodine and its compounds in bronchocele by the experience he had had of the efficacy of burnt sponge and the ashes of *Fucus vesiculosus* in this disorder. Knowing that both of these

medicaments contained certain proportions of iodine, he rightly conjectured that it was to the presence of this element that they owed their powerful curative properties. The exhibition of it was at first strenuously opposed by the faculty of Europe, who were naturally averse to using what they knew to be a powerfully corrosive poison; but the successful results obtained by Dr. Coindet at Geneva, and by Baup, Gimelli, Kolley, and other eminent men in different parts of Europe, soon brought it into general use. Dr. Manson, an English physician, deserves the credit of having first employed it on an extensive scale in scrofulous diseases. In large doses given internally, iodine acts as a very energetic irritant poison; in smaller and continuous doses, it exercises a general stimulative action, more particularly on the pulmonary and gastro-intestinal mucous membranes; also on the mammary, thyroid, and the other glands generally, and on the genital organs. Its salts are largely employed for their alterative effects in bronchocele, scrofula, cancer, syphilis, blennorrhagia, leucorrhœa, and other disorders of a similar nature. It has also been recommended by certain eminent practitioners as an emmenagogue. Applied externally, it acts as vesicant and discutient, staining the skin brown or orange, and causing itching, redness, and desquamation. Used as an ointment, it is absorbed, producing its characteristic effects. Inhaled, its vapour exercises an alterative action on the numerous membranes of the respiratory organs, which has been found very beneficial in cases of pulmonary phthisis. The principal officinal preparations are the *tincture*, consisting of iodine dissolved in alcohol; the *compound tincture*, iodine dissolved in a solution of iodide of potassium; *iodide of potassium*, the most used of any of these salts; *iodide of sodium*, which acts more energetically than the last, from containing eighty-five instead of only seventy-six per cent. of iodine; *iodide of ammonium*, which is more energetic than either, from being more easily decomposed; the *iodides of calcium* and *barium*, used as alteratives in scrofula; the *iodides of lead* and *cadmium*, employed in ointments in indolent scrofulous and syphilitic tumours; *iodide of silver*, in syphilis; *iodide of sulphur*, as an ointment in obstinate skin diseases; *iodide of iron*, which possesses the properties of both elements, and is much prescribed in scrofulous diseases of anæmic patients; and the green, yellow, and red iodides of mercury. Dono-

van's solution, a famous American remedy in syphilitic disorders, is composed of the iodides of arsenic and mercury in equal proportions. The *iodide of quinine* has been occasionally prescribed. *Iodoform* is also employed in bronchocele and scrofulous affections: it contains nine tenths of its weight of iodine, notwithstanding which its taste is mild. The whole of these preparations are made by Messrs. Huskissons; but it would, of course, serve no good purpose to describe their mode of preparation *in extenso*.

The first step in the manufacture is the rough iodine, which is produced from kelp or burnt seaweed. The various species of *Fucus* and *Ulva* thrown on the coasts of Scotland, Ireland, Guernsey, and Brittany, by the waves of the Atlantic Ocean, contain the largest quantities of this valuable element, the richest weed yielding from eight to fourteen pounds per ton, while the poorest realises no more than four or five pounds in the same amount. The principal manufacturers of rough iodine are Messrs. Paterson, Smith, and Ward, of Glasgow; Hughes, of Ireland; Tissier ainé et fils, and Cournerie and Co., of Cherbourg, Normandy. The annual amount of iodine produced in Scotland, Ireland, and Guernsey, is very great, a large proportion being exported to France and America. The fluctuations of iodine in point of price have been most extraordinary, the quotations varying from 4*d.* to 1*s.* per ounce in a single month. This has been caused by wealthy buyers holding back stock for better prices. It was lately at 3¼*d.* and 3½*d.*, which is lower than has ever been known. As met with in commerce, iodine is frequently adulterated with clay, alumina, &c.; but the loss oftener arises from its containing too much water. The amount of moisture is readily ascertained by a practised buyer, by pressing the samples between folds of blotting-paper, or by sublimation, and noting the loss. The solid matter present is detected by dissolving the iodine in alcohol. Cyanide of iodine is also a frequent accidental impurity, which rises during sublimation, and condenses in long white crystalline masses. Hughes's iodine is considered by most manufacturers to be the purest in the market, and always commands an advance of a halfpenny to a penny on that of other makers. Before Messrs. Huskissons undertook the manufacture of the salts of iodine, the principal source from which the largest supplies were drawn was the west coast of France and other parts of the Continent. The quality then

met with in commerce was of a very uncertain character, often containing iodate and carbonate of potash, chloride of potassium, and iodide of sodium. The crystals were in irregular spongy deliquescent cubes, or in dog's-tooth crystals, which mostly changed to a yellow or pink colour. One of the members of the firm, Mr. William Huskisson, however, went to work, and thoroughly devoted his whole time and energies to the production of a uniform, staple, and permanent product. After repeated trials and experiments, which may be numbered by hundreds, he succeeded in discovering not merely one, but several processes, which would effect the desired result, thus giving the manufacturer a choice of methods according to the different materials he has to work upon. One method peculiar to this firm is to procure pure hydriodic acid in the first instance, by decomposing iodide of zinc with oxalic acid, and then forming the salts as they may be required. This process of obtaining pure hydriodic acid has certain advantages over the ordinary method of distilling iodide of potassium with dilute sulphuric acid. Another method is by passing sulphuretted hydrogen into a concentrated solution of iodine. The process of obtaining iodide of potassium by the decomposition of iodide of calcium with sulphate of potash originated with this firm, and produces excellent results. The samples of iodide of potassium crystallizing in the vats at Messrs. Huskissons' works are amongst the most beautiful objects in chemical manufactures. These ivory-like cubes are often from one and a half to two inches square, and will, with care, split into laminæ as thin as writing-paper. The large cubical crystals shown at the International Exhibition by the firm were thought by many to be picked samples; but larger and more perfect cubes are every day turned out of the crystallizing vessels in hundreds. Mr. William Huskisson has made the study of crystallography peculiarly his own, and uses it daily to determine the purity of any particular salt by a mere glance at its colour, opacity, sharpness of angle, size of crystal, &c., without being obliged to have recourse to the test-tube.—We have lingered so long over the iodides, that we have but little time left for the consideration of their brethren, the bromides. The bromides are very similar in most of their properties, both chemical and therapeutical, to the iodides. The best bromine is obtained from France, being freer from chlorine and iodine than that procured from other sources.

Bromide of potassium is replacing iodide of potassium for many disorders, more especially those of a syphilitic character. Bromide of iron in solution has also been very successfully employed by various practitioners as a tonic alterative. Chloride of bromide is mentioned by Parish as a powerful stimulant to the lymphatic system in minute doses. The uses of iodic and bromic compounds in photography need only be alluded to, the subject being of too technical a nature to be treated of fully in a popular work.

We have said nothing about the many admirable mechanical appliances used in Messrs. Huskissons' manufactory, feeling that the chemical portion of the subject would be far more interesting to our readers. It would be impossible to describe in detail the various crushing and stamping mills, boilers, evaporating pans, &c., without going fully into the subject. Evaporation is carried on in jacketted pans, most of which are without seam or rivet, by means of coils of copper, iron, and lead pipes. The whole of the steam generated by the engine-boilers is utilized. After leaving the engines, it passes through coils of pipe contained in stills filled with water. As the water boils, the vapour is collected, and forms one of the sources of distilled water, this article being supplied to all the customers of the firm gratuitously. In order to obtain a constant supply of water, Messrs. Huskissons have lately sunk a well into the chalk, many hundred feet deep, and capable of giving unlimited quantities of water containing a minimum of saline matter. High-pressure steam is also used as a heating agent with very economical results.

Concluding our visit by the examination of some choice specimens of crystals of different salts, we cannot help recurring to the old reflection, which we cannot repeat too often, that the more the theoretical truths of science are brought to bear on practical manufactures, the more perfect will be the result.

The examination of the different processes carried on at Messrs. Huskissons' works has been a task of no ordinary lightness, involving many lengthy visits and conferences; and we should be most ungrateful did we not acknowledge publicly the debt of thanks that we owe to the firm generally for the facilities they afforded us of gathering the information we needed, but most especially and particularly to

Messrs. William and John Huskisson, jun., for the pains-taking kindness with which they always received our visits, and placed their time and knowledge at our disposal.

PERFUMES AND PERFUMERY.

The employment of perfumes is, no doubt, almost coeval with the existence of organs wherewith to appreciate the pleasure to be derived from their use. The couch of our first parents was probably strewn with the fragrant blossoms of the rose, the jasmine, and the violet, long before the unwholesome and insufferable stench of the sacrificial victims rendered the burning of odoriferous gums at the altar a necessity to their descendants as a preservative of health and comfort. Besides employing fragrant incense during their religious sacrifices, the whole of the Eastern nations have from the remotest ages been accustomed to the secular use of perfumes, both as antidotes to the baneful effects of the masses of quickly-decaying animal and vegetable matters which are so unavoidably frequent in all hot climates, and as refreshing stimulants during the hottest parts of the day. From the East this pleasant practice soon spread into Greece; and the fulminations of Socrates, Solon, and other philosophers, against the use of perfumes by the Greeks, show us to what a pitch the luxurious fashion was carried. The Romans soon learnt the art of making perfumes from their refined neighbours; and the sensual Capuans were so addicted to scenting their houses, furniture, horses, slaves, and persons, that one large street of the city was entirely occupied by perfumers. In the early Christian Church, perfumes were used in the form of incense,—a practice which remains in the services of the Roman and Greek Catholic Churches to the present day. During the Middle Ages the use of scents in all forms was universal, as is evident from the frequent allusions made to them in the writings of that epoch. The English Puritans, like their classic prototypes the Lacedemonians, discountenanced the use of scents as an unnecessary and sinful luxury; and the manufacture of perfumery in this country

declined until the beginning of the present century, when the growing demand for perfumes by the Court, added to the stoppage of Continental supplies during the French war, put English manufacturers on their mettle. They had, however, legislative restrictions of a serious character to work against, in the form of the glass, paper, and spirit duties, two of which have been lately removed. The Exhibition of 1851 showed the world that British perfumers could pretty well hold their own against their foreign competitors, and in 1862 the trade was thought of sufficient importance to receive separate classification and a distinct jury. Few visitors to the Exhibition of last year will forget the tasteful show made by the exhibitors of Class IV. D. in the Eastern Annex; we have reason to know that the consumption of British perfumery, both at home and abroad, has been greatly increased by the display of what our manufacturing houses were capable of doing on that occasion. The *science* of perfumery has greatly progressed of late years, and now, instead of mingling odours without rhyme or reason, the perfumer is guided by certain fixed principles in mixing his scents. The manufacturer has also received important aid from the progress of organic chemistry; and although as yet the laboratory has not taken the place of the flower-garden, still the experiments of certain perfumers, who are also scientific chemists, seem to indicate that some of the organic ethers may be made to yield odour of a sufficiently delicate nature to be used in perfumery.

A few years since, a first-rate pharmacist would have thought it *infra dig.* to sell perfumes. This silly notion has long since disappeared, and there are now few fashionable chemists' shops which have not an important portion of the counter set apart for the display of these harmless luxuries.

A VISIT TO MESSRS. PIESSE AND LUBIN'S "LABORATORY OF FLOWERS."

The home manufacturing premises of Messrs. Piesse and Lubin are situated at No. 2, New Bond Street, and from their architectural embellishments form one of the leading ornaments of that fashionable promenade. Besides this establishment, they have extensive flower farms near Nice,

in the south of France, where they grow large quantities of roses, violets, and other odoriferous flowers, which are manufactured on the spot into greases, oils, ottos, and extracts. At Mitcham, in Surrey, they have large lavender gardens, besides an extensive bonded warehouse at the London Docks, where they make their perfumed spirits for foreign and colonial consumption. Their flower-gardens at Nice produce violets, roses, jasmine, tuberoses, jonquils, orange-blossoms, acacia, and numberless other fragrant flowers, from which scents are extracted principally by four processes: 1. *Expression*; 2. *Distillation*; 3. *Maceration*; and 4. *Absorption* or *Enfleurage*.

The first process is used in the case of plants whose parts contain large quantities of odoriferous essential oil, such as lemon, orange, and citron peels. These portions of the plant are put into a press, which is in principle an enlarged tincture press, consisting of an iron vessel of immense strength, fitted with a perforated false bottom, on which is placed the material from which the oil is to be expressed. A powerful screw, connected with a piston, fitting into the vessel and worked by a lever, forces the substance closely together, squeezing out the liquid portions. The oil obtained is of course largely contaminated with water extracts, from which it is separated by decantation. Distillation is adopted when the amount of essential oil is less than in the last instance. The distillation of oil of lavender may be taken as an example. The leaves are thrown into a still either heated by steam or by the naked fire, and containing a large quantity of water. As the heat rises, the steam passes into the refrigerator, carrying with it the essential oil of the plant. By an ingenious contrivance, patented by Messrs. Drew, Heywood, and Barron, the condensed steam is made to re-enter the head of the still, leaving behind it the essential oil in the refrigerator, thus allowing the same water to be used over and over again. In the stills employed by Messrs. Piesse and Lubin, steam at from ten to fifteen pounds pressure is used as the source of heat, it having been found that the French method of working by the direct action of the fire is liable to give the distillate a peculiar empyreumatic or burnt odour. The third method is used for finer odours, such as the rose or violet. A certain quantity of purified beef or deer suet is mixed with purified lard, and put into a clean porcelain or metal pan.

Steam heat is applied, and the flowers from which the odour is to be extracted are carefully picked and thrown into the melted fat, wherein they remain for one or two days. The fat dissolves the essential oil or other odoriferous principle contained in the flowers, and of course becomes thereby highly perfumed. The process is continued with fresh portions of flowers until the grease is of the desired strength, the different strengths being indicated by the French manufacturers by numerals. Where perfumed oil is required, fine olive oil is substituted for fat. The oils thus prepared are known as the *huile antique* of such and such a flower. The orange, rose, and cassia pomades and oils are prepared by this process. The fourth process of *absorption* or *enfleurage* is the most important of them all; and as little is known of it in this country, a minute account of it will interest our readers. We also call their attention to it for another reason. There are many of our English flowers whose odours have become household words, but which have never been introduced largely into perfumery on account of the difficulty of preparing scents from them by the ordinary means of distillation or maceration. As examples of them, we may mention the wall-flower, the lilac, the cowslip, and twenty others. The process of enfleurage would, no doubt, suit them admirably, and we recommend our readers most strongly to make a few experiments in this direction. The process is used for those flowers whose delicate odours would be destroyed or changed by heat, and yields all those fine pomades and oils known as "French pomades and oils." The whole operation is conducted in the cold. Square frames, three inches deep, two feet wide by three feet long, are provided with glass bottoms, upon which is spread a layer of fine grease about a quarter of an inch thick; on this are sprinked the flowers from which the scent is to be extracted. Another frame similarly charged is placed on this, and so on until a large pile is made. The flowers are changed from time to time during the whole of the blooming season. Oils are prepared in a similar manner, coarse cotton cloths soaked in the finest olive oil being substituted for the layer of grease, and a wire gauze framework being used instead of glass. There are many odours, such as Tonquin bean, ambergris, vanilla, castor, and a number of others, which are extracted by soaking the substance in strong alcohol.

Although the farms of Messrs. Piesse and Lubin at Nice supply them with large quantities of raw material both for consumption and sale, there are many substances which they are of course obliged to import or buy in the markets,—such as ambergris, civet, and vanilla, the essences of tropical plants, &c.

The warehouse at the London Docks is used for storing and mixing perfumes in bond for the colonial and foreign markets; and as precisely the same processes, and many more besides, are carried on at the manufactory at Bond Street, we prefer giving a description of the latter establishment. Descending from the well-appointed and tastefully arranged shop to what we supposed must be a dark cellar, we are agreeably surprised to find ourselves in a large, light, but somewhat odoriferous laboratory, in which a number of men and boys looking like very clean *chefs de cuisine* are engaged in various employments. Our attentive conductor takes us first into a large cellar, running half-way under Bond Street, and containing an immense number of tin and copper cases. These, we are informed, contain the pomades, oils, ottos, and extracts manufactured at Nice and elsewhere, which require to be kept as cool as the choicest *Château Margaux* or Comet Port, for fear of losing their delicacy. From the cellar, which contains some thousands of pounds' worth of raw material, we pass back to the laboratory, and inspect the method of extracting the essential oil from the pomades prepared by maceration or enfleurage. We should, perhaps, premise that these pomades are very much stronger than ordinary pomatum, a small piece the size of a walnut containing sufficient essential oil to perfume a large quantity of grease. The pomade being taken out of its case, is placed in an iron cylinder perforated at the bottom with a series of slits, and pressure is applied by means of a closely-fitting piston to the top of the grease, which is forced through the slits in a number of long ribbons. These ribbons are macerated in the very best alcohol for several days, until nearly the whole of the essential oil is extracted from the pomade. The spent grease still, however, retains sufficient essential oil to render it useful for making pomatum. The solution of essential oil in alcohol thus obtained forms the ordinary *extrait* of the perfumer. The *extraits* (by the way, the nomenclature of perfumery is as yet entirely French), when judiciously combined, form the so-called

bouquets, and the thousand and one other scents with endless fanciful names that are now so fashionable. Here it is that the skill of the olfactory artist is exerted. Odours have a certain resemblance to musical notes. Without much stretch of imagination, we may look on the light and sharp verbena as a high note, and on the dull and heavy patchouly as a note to be placed in the lowest bass, while the mellow almond and tuberose seem to occupy a place between them. The injudicious mingling of odours is, therefore, like the inharmonious blending of notes and colours. Again, by the proper combination of simple extracts, other simple odours may be very successfully imitated. Thus, a mixture of the extracts of orange-peel, lemon-peel, and lemon grass, gives a perfect imitation of the simple extract of verbena. Besides the extracts obtained from the enfleurage pomades, there are also ottos, essential oils, and alcoholic extracts almost without number, all of which are used for the same purposes. The preparation of the various bouquets and mixtures which Messrs. Piesse and Lubin have so successfully introduced to the public under the familiar titles of "Frangipani," "Kiss-me-quick," "The Trump Card," &c., being merely a matter of mixture and filtration, need not be described.

Several stills are at work all heated by steam; but as our readers are well acquainted with the process of distillation, we need not stop to describe them.

In one corner of the laboratory is a soap-boiler, also heated by steam. In it is slowly simmering a mixture of curd, oil, and marine soap, the judicious union of the three forming a toilet soap, having the necessary qualities of fine grain, moderate hardness, and lathering properties, besides the capability of preserving its shape without shrinking. When the mixture reaches a certain degree of fluidity, the desired scent is mixed in with a crutch, shaped like an inverted L, curved to fit the hollow bottom of the pan. This is worked about until perfect uniformity is produced. The scent having been "crutched" in, the colouring matter is added, if necessary, in the same manner, and the whole is turned into the "frame." The "frame" is a box made in horizontal sections, the width of the intended bar of soap. When the soap is sufficiently cool, it is cut into slabs by a wire guided by the sections of the frame. The slabs are allowed to cool for two or three days, and are then cut into

bars, and lastly into squares, which are stamped with various shapes between brass dies. When the scent to be added will not bear heat, the boiler is dispensed with, the mixture of soaps, scent, and colouring material being made in a mortar. Transparent soap is made by dissolving dry soap shavings in alcohol, scenting, casting in appropriate moulds, and finally drying in a warm situation. The duty on spirit acts very prejudicially against the manufacture of transparent soap in this country, and will continue to do so until the Legislature allow spirit to be used for manufacturing purposes free of duty. Methylated spirit has been tried for the purpose, but, as might be expected from its abominable odour, without success. Besides ordinary toilet soaps, Messrs. Piesse and Lubin manufacture medicated soaps very largely. The sulphur, creasote, and mercurial soaps are much used for skin diseases; and those who wish to fancy themselves at the sea-side without leaving their own toilet-tables, cannot do better than use the iodine and bromine soaps made by the firm.

In different parts of the laboratory are various troughs, mortars, and presses, to describe all of which minutely would occupy too much time. At one, a boy is mixing various powdered woods to form the stuffing for sachets; another is performing the same operation with ground almonds, and orris-root powder for almond meal. Further on, a man is stamping delicate sea-green masses of soap with the name of the firm. In a far corner of the laboratory is a small room something like a pantry, in which are closely kept under lock and key the most valuable raw materials used by the perfumers. The shelves and drawers contain bottles of rare ottos and essences seldom seen in this country, nearly all of which smell most vilely in their concentrated form. Amongst them we may mention true Turkish attar of rose, worth—we are afraid to say how many guineas an ounce; oil of birch bark, used for perfuming Russia leather, and rarely seen in this country; musk pods in their odd silk-covered boxes, with their chop papers written in choice Chinese inside; civet, which, in large quantities, has a stronger stercoraceous smell than any stable; various organic ethers which have been made the subject of experiment, and which give one temporary asthma; some splendid specimens of vanilla pods, nearly a foot in length, covered with long plates of benzoic acid:

and so on, until the nerves of smell are bewildered, and we are glad to escape to the upper floors, where the only smell to be met with is that of brown paper enclosing thousands of dozens of bottles and fancy boxes. On one of the floors, a boy is constantly employed in making the "ribbon of Bruges," which is now so largely used as a fumigatory. It consists of tape soaked first in a solution of nitre to give it smouldering properties, and afterwards drawn through a solution of benzoin, myrrh, and other odoriferous substances. The ribbon is cut into yard lengths, and put into boxes provided with a slit in the upper cover. The ribbon is drawn out to the length of an inch or so; lighted and blown out, it smoulders down to the slit in the box, gradually diffusing a pleasant odour throughout the room. The "ribbon of Bruges" is one of the numerous little tasteful "oddments" for which the house of Piesse and Lubin has rendered itself famous. Some idea of the favour in which this article is held, may be gathered from the fact that it is frequently produced at the rate of two miles and a half a day. Messrs. Piesse and Lubin have made the pistachio nut their especial property, by the way in which they have utilized its numerous products. This nut, which has hitherto been only known to us in connection with *pré-salé* mutton, contains a very bland, colourless oil, which exists in it in such quantities that it may be squeezed out between the thumb and finger. This oil serves not only as a hair oil, but also forms an excellent soap. The nut when ground makes a first-rate meal for the face and hands, in lieu of the ordinary violet powder; and when ground with scented water, forms a cream which is used as an anti-irritant for the skin in hot weather.

Passing down once more into the shop, we are shown a number of little fancies, which take immensely with juvenile fashionables of both sexes. The finger-rings provided with a little jet of scent for odoriferous practical joking, were a short time ago immensely popular. They have now numberless companions in the shape of "nuts to crack"—walnuts containing tiny bottles of scent; perfumed shells; scented gems; "rusma," for taking off the hair; "philocome," for putting it on again; "schnouda," a white grease containing alloxam, which turns a beautiful carmine when rubbed in the skin for a short time; "kohl," for the eyebrows; "henna," for the nails; and that horrible invention of

the Empress Eugenie's—gold powder for hiding the hair.

We pass once more into the evil-smelling town, much pleased with our visit to the "Laboratory of Flowers," thankful for the painstaking courtesy we have received, but with our nose in such a state of confusion that we question whether we shall ever again be able to tell the difference between violets and sulphuretted hydrogen, *eau de Cologne*, and *eau de Tamise*.

MESSRS. CLIFF AND CO.'S CHEMICAL STONE-WARE WORKS, LAMBETH.

The materials employed in the manufacture of Chemical Stone-ware are chiefly white clays, obtained from the counties of Devon and Dorset, with a certain amount of kaolin, or China clay, from Cornwall; and for glazing purposes, a proportion of Cornish stone, felspar, &c. To the former are added sand, ground flint, and other clays of a more or less infusible character, according to the quality required, from Maidstone; Wortley, near Leeds; and Newcastle-on-Tyne; and for certain kinds of ware, a large proportion of pounded broken earthenware, technically known as rough stuff, or grit, is used.

On referring to the "Mineral Statistics" published by the officers of the Geological Survey of Great Britain and Ireland, we find that the various kinds of pottery and fire clays produced in England alone, in the year 1858 amounted to upwards of 400,000 tons, and that the estimated value was nearly £300,000. These totals do not include the clays used for the manufacture of bricks and tiles.

The Devonshire clays are purer than those of Dorset, and are used for the manufacture of the smaller wares. Those of Dorset contain a certain admixture of lime and iron, rendering them less pure, and consequently of less value. They are, however, used in combination with a certain amount of the Devon clay for the larger vessels.

The articles intended for the use of chemical manufacturers require great care in making, both as to the proper proportions of the materials employed and their due admixture. These vessels have frequently to resist the

action of the strongest acids, and that at a high temperature, consequently it is absolutely necessary that they should admit of a certain amount of expansion and contraction without breaking. This quality is obtained by the mixture of complex materials, those of each manufacturer varying from those of others.

The clays employed at these potteries are sent from the pits in cubical masses, weighing usually about thirty-five pounds each. After having been well dried, these are reduced to powder in a crushing mill. The due admixture requisite to form the articles required is then thrown into a pug mill, which is an upright cylinder, about six feet deep by two in diameter, having a perpendicular shaft running through it. This shaft, which is made to rotate by steam power, has a number of blades set on it, forming a kind of screw. These arms or blades so work amongst the powdered clays, as to mix them intimately with water, which is admitted at the discretion of the workman; and, by their continued action, they force the clay out of the bottom in a plastic state, of such uniform consistency, and so free from bubbles of air, that it is fit for the workman who fashions it into the required form on the potter's wheel. This is a kind of lathe, formed of a shaft, having a vertical instead of the usual horizontal position; on the upper extremity of the upright shaft is fixed a small circular disk, which revolves with it. On this disk the workman places the lump of prepared clay, and, by pressure with his hands, aided by a few simple tools, fashions this yielding material into any required shape with a truly marvellous degree of dexterity and rapidity. It is with the aid of this simple contrivance that almost all circular articles are made, from penny ink-bottles, which are sold at 2*s.* 6*d.* per gross, to the enormous vessels manufactured by Messrs. Cliff, some of which are capable of holding 800 gallons.

The vessels having been made, are placed in the drying-room to become thoroughly dried; after which, the double glazed stone-ware, such as spirit-jars, druggists' pots, &c., are dipped in liquid glaze, and taken to the kiln to be burned. This kiln, as usually constructed, is a large circular room, about ten to fifteen feet in diameter, and fourteen feet high; it is lined with the best Wortley fire-bricks, and has at its sides a number of openings to admit the heated air from the fires. It has also apertures in the roof

to allow the escape of the smoke. The articles to be burnt are placed in the kiln, piled up on one another, if the goods are small, or, if large, singly on slabs or quarries. The opening is then built up and carefully cemented over, then the fires are lighted, and are gradually increased until every article in the interior becomes heated to an intense white heat, which process takes, with a fifteen-foot kiln, from forty to fifty hours, consuming ten tons of coal. If the articles are to be salt glazed, a quantity of very coarse salt is thrown in through the holes left in the roof of the kiln, and into each fire-hole, shortly before the termination of the firing. This salt is at once converted into vapour by the intense heat, and is decomposed; the soda of the salt unites with the silica of the clay, and forms a fusible glass or glaze upon the surface. So indestructible is this glazing, that articles thus protected have been found to resist the action of the nitrous acid of commerce for twenty years without deterioration. After the glazing operation the kiln is carefully stopped, to prevent draughts of cold air, and is then allowed to cool from thirty to forty hours before it is opened and the articles removed.

For other kinds of glazing a different process is employed, the vessels being dipped into a composition of materials that melt during the firing into the kind of glaze required. It may be noticed that many stone-ware articles are of two colours—as, for example, a brown top with a buff-coloured base; this dark top is given by the addition of a proportion of manganese to the glaze.

Messrs. Cliff have introduced a new kiln which has effected several improvements in the process of firing. For instance, the articles are not exposed to the direct action of the fire, but are enclosed in an inner kiln, the fire playing between the two, and the draught also traversing numerous hollow pipes which are connected with a hollow bottom communicating with the furnace, and support the shelving in the interior; thus the articles are raised to the required temperature without being exposed to the immediate action of the flames, and are burnt and cooled more quickly and more evenly than by the old process, while at the same time the kiln holds more goods, and has much less gear to remove after each charge.

Among the articles manufactured at Messrs. Cliffs may be mentioned the condensing worms, formed in all sizes

from eighteen to fifty-four inches in height, and from $\frac{5}{8}$ inch to upwards of three inches bore. The worms are made by curving pipe of the required diameter to the proper circle sufficient for one coil; these coils are, when stiff or "green," built up one over the other to the height required.

In connection with the subject of distillation, we may state that we saw in the process of manufacture a huge condenser, consisting of a series of straight pipes, each six feet in length by three and a half inches diameter, to be joined by curved end pieces. Amongst other large-sized novel articles we noticed several stone-ware rollers, each six feet long, to be used by paper makers; these had a splendid face, and were most valuable as not being liable to be acted upon by the chlorine used in bleaching the paper pulp.

So numerous are the chemical wares, such as retorts, receivers, stone jars, percolators, tincture jars, &c., &c., that a few only can be alluded to. Messrs. Cliff and Co. are the patentees of a peculiar air-tight stopper, which is formed of a small segment of a sphere. These stoppers are now adapted to openings of all sizes, even up to those of eighteen inches or two feet in diameter; this renders these stone-wares much more useful than they would be otherwise, as when used for spirits and other volatile substances they possess the advantage of not allowing any loss by evaporation.

These spherical stoppers are turned in a lathe after being burnt, and are fitted to the jars by grinding with fine emery powder, each jar and lid being afterwards lettered to correspond. The adaptation of these air-tight lids to stoneware jars of all sizes, is of great advantage to dealers in volatile drugs, and those liable to spoil by exposure to the air.

It would be impossible to enumerate all the useful implements and appliances that are made of stone-ware, from bottles at less than a farthing each, and cheap infusion pots at ninepence, to condensing worms at six guineas, and vessels of enormous bulk at a much greater price.

GLASS WORKSHOPS.

The Glass Works of Messrs. Chance Brothers and Co., Spon Lane, near Birmingham.—The Glass Manufactory of Messrs. Defries, in Houndsditch.

GLASS WORKSHOPS.

THE GLASSWORKS OF MESSRS. CHANCE BROTHERS AND CO., SPON LANE, NEAR BIRMINGHAM.

NOT having "read up" the subject in the British Museum before leaving London, and having now no time to gather a prefatory page from such works of reference as we might find available in the admirable library at Birmingham, we start at once on the journey to Spon Lane, scarcely regretting our previous negligence—first, inasmuch as we shall be able to learn from the high authority of the Messrs. Chance themselves everything which can serve to interest the general reader; and, secondly, because even a slight description of a progress through the works and the process of manufacture will occupy all the space at our disposal. Of the first invention of glass it is enough to say that it has been ascribed respectively to Egypt, Israel, Nineveh, and Phœnicia. It is tolerably certain, however, that the art existed at least three thousand years ago, since, from the discovery of pictures and hieroglyphic inscriptions, as well as glass ornaments, this early date has been ascertained as one in which the manufacture was frequently practised, and the existence of the Glain Neidyr, or Druidical glass rings, found at Stonehenge and elsewhere, proves the introduction of such ornaments into Britain at a very early period. The precise epoch in which window-glass was first introduced is uncertain, since, although several panes were discovered in the excavation at Herculaneum, the Romans used for the purpose (when they used anything) a sort of "talc," which is a semi-transparent fossil. Glass came to be used for this purpose, however, and was introduced into England between

the seventh and eighth centuries. This, of course, was only for the filling of a few cathedral windows, the windows of palaces, churches, and ordinary houses being still furnished only with oiled paper, sheets of linen, and wooden lattices or louvres. The manufacture was not established in England until the fifteenth century, and even after that time the glass of Venice, Bohemia, Spain, and France was of a very superior description to our own. From the time in 1670, when many of the foreign workmen were brought to London, however, the art was rapidly improved, the manufacture became of immense importance, and a bounty was paid to the exporters which enabled them successfully to compete with foreign markets. This bounty, however, has been abolished, and, fully able to sustain its own position, our glass manufacture has become one of the most important branches of national industry. If there could possibly be any doubt of this fact, the enormous works at Spon Lane, close to the station at which we are by this time deposited, would surely be sufficient proof to satisfy the most determined sceptic. There, intersected by the canal which we are about to cross, and divided by lines of railways, the stupendous range of workshops, forges, and ovens extends over an area of twenty-four acres; while from amidst the separate piles of building there rise a score of shafts and chimneys—the steeples of this great temple devoted to labour and to art. It will be some indication of the extent of the business carried on at the Spon Lane works to remember that the glass which covered the Great Exhibition of 1851 was supplied by Messrs. Chance, that this occupied only the "sheet-glass" department, and that 300,000 of the panes, 49 in. by 10 in., were supplied in the course of a few weeks without in any way interfering with the ordinary business.

We are so fortunate as to obtain the valuable guidance of Mr. Henry Chance, who himself accompanies us over the greater part of the works; and as melting the "metal"—metal in this instance meaning principally sand, soda, and lime, of certain qualities and certain proportions—is preliminary to the very existence of the glass which is formed by their combination, we are naturally directed to the consideration of "pots."

Here they are, then, in a large and almost empty workshop, where no machinery is admitted, because it would be ineffectual in the process of pot-building. In the centre of

the floor is a great mass of Stourbridge clay, which is kneaded by the foot of a man who treads it into a tempered mass; then, with a wooden spatula, it is taken piece by piece to the moulder, who gradually builds what looks something like the outer crust of a gigantic pork-pie. These pots are about five feet in diameter and forty-two inches high, and many of them weigh more than a ton. When completed they are lowered through a trap into a warehouse beneath, and thence, after months of drying, are taken to the kiln, or "pot-arch." After long and careful baking, they are removed from the kiln and carried away, hanging on the end of a sort of lever upon wheels. The cost of each pot is about £5, and there are generally from 400 to 500 of them kept ready for use. The pots hold about two tons of metal each, and, after following them through the fiery ordeal, we are prepared to witness them in operation at the glass furnace.

CROWN GLASS.

Commencing with crown glass, we enter an immense building where the great furnaces are glowing and roaring behind the iron screens which conceal the vast cauldrons where the glass is being formed from the metal. A terrible task, it would seem, that of setting these mighty crucibles on the furnace in all the withering glare and heat. As it is, we advance cautiously to the screen, and at a moderate scorching distance look through one of the small round apertures in the iron into the furnace mouth, feeling like a duodecimo Dante, catching a glimpse of a private inferno in a peep-show. In the centre of each pot is a ring of fire-clay, which floats on the surface of the molten glass, the use of which is to reduce the surface from which the impurities are skimmed, and to prevent the exterior surface, which becomes stiff in working, from mixing too freely with the interior surface and injuring its uniform density. When once the glass is in a thoroughly fluid condition the furnace is gradually cooled until the contents of the pot are in a fit state to be worked by becoming of a somewhat greater consistency, then the screen is removed, and the gatherer advances boldly to the front of the awful fiery chasm, whose glare lights up the whole area with an intense glow.

Taking his great hollow iron rod in his hands, he places

the end of it inside the ring of fire-clay, and by a twirling motion collects on the end of it a pear-shaped lump of glass, only removing it to turn the rod gently round and round as it rests upon a stand or "horse." This allows the surface of the lump to cool sufficiently for a second gathering, and, the lump once completed, the tube is cooled with water, so that it may be freely handled, and the glass at the end is rolled upon the "marver" (a metallic bed) until it assumes the form of a cone, the apex of which is the bull's-eye, which afterwards appears in the centre of the "table," or disc of glass. While it is being rolled a boy blows down the tube and expands the glass into a small globe, after which it is again heated and blown until it resembles a Florence flask in shape. At this stage the part of the lump nearest the end or "nose" of the pipe is rolled upon the edge of the marver, and thus prepared to become the edge of the final circular plate. After being once more heated and expanded into a large globe, the future bull's-eye being kept in its place opposite the end of the pipe by means of a piece of iron terminating in a small cup, the glass is presented to the fire and kept rapidly revolving until the front of the globe is flattened, and the shape is changed to that of an enormous and somewhat "squat" decanter, the "bullion point" occupying the centre of the bottom, the neck still attached to the blow-pipe. This pipe is next laid across an iron rest, and another workman, bringing a long iron rod called a "ponty," having at the end a lump of molten glass, which has been moulded into a sort of cup by pressure on an iron point firmly attaches it to the bullion point. A piece of cold iron applied to the neck of the glass suffices (with a smart blow) to separate it from the end of the pipe, and the flattened globe now attached by the bull's-eye to the ponty undergoes the final process, an ordeal so fierce that the operator wears a mask as he stands in the blinding heat of a huge circle of flame, into which he thrusts the still whirling rod. As the heat further softens the glass, the centrifugal force produced by this rapid revolution of the rod causes the "nose," or outer axis of the globe, to expand; then the opening grows larger, the entire piece assumes for a moment the appearance of a ring with a double rim, and before the cause can be discerned, a wheel of glass is spinning at the end of the ponty. This "table" is carried off, laid flat upon a support called a "whimsey," and detached from the rod

by shears, and lifted with others, supported between iron frames, into the annealing kiln, where it remains from one to two days, until its fiery trial is completed.

Following it to the warehouse, we see the smooth, comely wheel of glass lying on a cushion, where it is divided by a diamond into two unequal parts, one of which contains the bull's-eye. The usual size of each table is 54 in. and its weight 13 lbs., the larger sizes involving considerable cost and trouble and manipulation. There are various qualities, which are announced at a glance by the inspector, who, by means of a staff of boys, assigns each to its proper place in the warehouse. A table of crown-glass of to-day, however, would be scarcely recognised as of kindred origin to a table of the earlier part of the present century. The principle of the process in each case is the same; it is the improvement of minute details that produces so different a result. To Mr. Hartley and Mr. Chance (who, from the years 1832 to 1836, gave to this manufacture their constant attention) is owing in a great measure its present status.

SHEET GLASS.

It is now necessary, however, to follow the processes of that sheet glass for which the Messrs. Chance have attained so great a celebrity; and although, from its great brilliancy of surface, the crown glass will still hold its position, yet the great size of the sheets obtained from the cylinders, whose formation we are about to witness, has already enabled them to supersede it for most ordinary purposes, as well as for some others to which the "crown" is not applicable.

Once more we stand in the intensely hot breath of the furnace. The gatherer holds a lump of glass on his pipe, which he carries to a block of wood hollowed out in such a way as to admit of the expansion of the lump by the blower to the diameter required for the cylinder to be afterwards formed. The block is sprinkled with water to prevent its charring and to avoid scratching the glass, and from this the piece is taken at once to the blowing-furnace, a long, oven-like structure, containing in its front a hole for each blower, who stands on the edge of a sort of well, like one of the openings of a saw-pit. There are several of these pits at a little distance from each other, and here the blowers swing their pipes to and fro in order that the glass bulb may

extend to the required length. After it has been heated in the adjoining blowing-furnace, the spheroid is lengthened into a large glass cylinder, kept full of air by repeated blowing through the tube. Uniformity of substance and diameter in accordance with a given weight is attained with marvellous skill by the workman, who occasionally holds the cylinder above his head to check the glass from spreading out too freely; and, the proper size once secured, the end is opened, in the thin kinds, by exposing it to the fire, and, after blowing through the pipe, stopping the aperture, the expansion of the air bursting through the bottom, which is the weakest part. The opening is widened to the proper diameter by turning the cylinder to and fro in a vertical position with the glass downwards. The ends of the thicker cylinders are weakened by attaching to them a lump of hot glass, and the burst edges are trimmed with scissors.

The completed cylinder is now laid on a wooden rest, and detached from the pipe by the application of a piece of cold iron, the "cap" being removed in the same way at the place where a thread of hot glass has previously been bound.

Leaving the furnaces and crossing the road, we are somewhat startled to see two men carrying a sort of low sedan-chair, but entirely covered with canvas. It looks so awfully like somebody being taken to the hospital on a stretcher that we are induced to ask what accident has occurred, but on turning to make the inquiry remark other stretchers in the distance, and discover that it is a small party of glass cylinders, carefully protected from the dirt and air, on their way to an operation which splits them from top to bottom, by means of a rule placed inside, and a long-handled diamond, which instrument was first substituted for a red-hot iron by M. Claudet, the eminent photographer.

The operation of flattening leads us to a fresh furnace, or rather to a fresh series of communicating furnaces, into which it is introduced, after a preliminary warming in the flue, and placed by means of the iron "croppie" on the flattening tone, upon which is first laid a "lagre" or large sheet of glass. Upon this the cylinder lies with its split side uppermost, and, being quickly opened by the flame, falls back in a wavy sheet, to be flattened by the "polissoir," an instrument somewhat resembling a baker's "peel," but with a block of wood instead of a blade. The flattening-stone, running on wheels, is removed to the next compart-

ment, where the temperature is lower, and by means of the flattening-fork is lifted on to another stone (the cooling-stone), where it remains until it is sufficiently stiff to be piled on the edge in the annealing-furnace. On the first introduction of this manufacture, which was due to Mr. Chance and Mr. Hartley, who, in 1832, secured the co-operation of M. Bontemps, of Paris, at their own works, the size of the sheet was usually 36 inches by 20; the usual size now is 47 by 32. Some cylinders are blown to a length of 77 inches, but this can only be accomplished by first-rate workmen, the weight of glass at the end of the pipe amounting to 38lbs., while the ordinary weight is not more than 30lbs.

GRINDING AND

Having seen the manufacture of the material, we have yet to visit the enormous area of workshops in which the processes which prepare the glass for various purposes are carried on by beautiful contrivances and adaptations of machinery, all of which have been the invention of Mr. James Chance.

Amongst these the means of grinding and polishing the sheet glass is one of the most interesting. Minute as is the difference between the lengths of the inner and outer surfaces of the cylinder just completed, these surfaces do not lie in parallel planes when that cylinder is reduced to a sheet, and this, in such a material, is sufficient to cause a slight waviness and inequality of surface—a difficulty considered almost insurmountable until Mr. Chance conceived the plan of laying each sheet upon a flat surface covered with a piece of soft damp leather, which, acting on the glass like the toy known as a "sucker," creates a vacuum and leaves the sheet perfectly flat. Two sheets are thus placed and turned face to face, horizontally, with a supply of sand and water between them, while, by means of peculiar machinery, the two faces rub each over the other in all directions. It is by this process that the beautiful window glass of modern houses is obtained of a quality which, while it is inexpensive, is little, if at all, inferior to plate glass in its clearness and illuminating quality.

After passing through a workshop where everything is coloured red from the powder used on the rubbers for

polishing the glass after grinding, we are shown the process of "obscuring" those solid, corrugated windows which may be seen at railway stations, or those skittle-ball lumps of glass let into the decks of vessels.

OPTICAL GLASS.

One of the most important operations in these works is the manufacture of that optical glass for which the Messrs. Chance have attained a high reputation. A single melting of the material from which this is made lasts five days, during which time the metal is constantly worked in order to clear it and free it from impurities. The whole mass is then allowed to cool, and a large lump of glass is drawn out, varying in weight from 6 cwt. to 12 cwt. This mass is polished and sawn in pieces of pure glass, varying in weight from a few ounces to several hundred pounds. These are again heated in a kiln, where they are moulded into the shape of discs of the required size and thickness. The principal points to be attained are complete freedom from veins, absolute homogeneity of the whole mass, and perfect annealing so as to avoid polarization of the rays of light. Rough discs only are manufactured by Messrs. Chance. These are afterwards ground and polished by the optician, and vary in value from a few shillings to £1000 each. At the Great Exhibition of 1851, and afterwards in the French Exhibition of 1855, Messrs. Chance exhibited discs of the enormous diameter of 29 in., the largest ever produced. Both of these were purchased by the French Government for £1000 each.

LIGHTHOUSE APPARATUS.

So far we have been describing processes which, although novel in some respects, and truly interesting, have a general similarity to those adopted in other glassworks, the difference being chiefly one of scale. But now we are introduced to a manufacture which is unique in Great Britain, and only elsewhere to be met with in France—a manufacture from which emanate the useful and the beautiful as kindred and inseparable spirits; where the highest faculties of the mind and the deepest sympathies of the heart have equal place; and where the genius of humanity inspires and blesses the genius of science.

We are standing in the lighthouse-works, in the department where the optical apparatus on the dioptric or lenticular system is prepared. Surely every visitor to the Great Exhibition remembers Messrs. Chance's lighthouse in the nave. That striking object consisted of two main portions—the metal lantern or light-chamber, and the lenticular glass erection enclosed in it. We are now gazing on the elements of a glass erection like this, the prisms and lenses in almost their first stage of manufacture, in a long, spacious building crowded with what seems an inextricable mass of machinery—wheels, shafts, bands, rubbers, "radial arms"—whirring, rolling, hissing, rumbling, vibrating—a very chaos of animated iron, and, as it were, a torture-chamber of art. For, bound upon great massive circular tables, whirled round with unerring and inevitable sweep, like the stroke of fate or the dreadful circle of the condemned lovers in the Dantean Inferno, lie the zones of glass being slowly and surely ground into perfect accuracy of form and polished into perfect translucency of surface. All these prisms and lenses have been cast in iron moulds in a glasshouse, according to certain shapes mathematically determined, and have been placed on these revolving iron tables, where, fixed in a frame or bed of plaster, and acted on by emery and rouge, they receive that last degree of completeness which fits them for their gun-metal framework where they are arranged in panels—these being further connected by a wrought-iron or gun-metal armature, the result is that imposing instrument called a dioptric light, a symmetrical structure of radiant glass, like a gigantic beehive or bird-cage, one of the largest size being about 10 ft. in height and 6 ft. in diameter, and worth, with its accessories, about two thousand pounds; or, with its protecting lantern, about three thousand pounds.

Having learnt all this, we pass into the adjacent fitting-shops, where the metallic portion of the apparatus and the lantern is prepared and fitted. The first we enter is bristling with machines of all shapes, sizes, and powers; planing, slotting, turning, drilling, and—start not, reader—*kicking*, for a kicking-machine is actually here, so called from its peculiar motion, and an implement used in connection with it is consistently termed a saddle. It is, however, we are told, perfectly obedient to its master, and kicks through all its work in the most methodical and satisfactory manner.

The adjoining shop is devoted to the erection of lanterns and lightrooms, lamps, and rotatory machines. Here rise up in due gradation cast-iron walls lined with mahogany, gun-metal framework, and copper dome crowned by ventilating-cowl and wind-vane, the whole forming the temple wherein the delicate but enduring glass apparatus is enshrined, which in its turn contains, placed exactly in the centre, the one large four-wicked lamp, and which directs and concentrates all the rays from that lamp into one or many beams or flashes, to guide and gladden the mariner far out at sea.

We are next conducted into the third shop (the filing department), where we see workmen busy with that simple handtool, which as yet no machinery can supplant, upon the gun-metal frames that hold the optical glass; and thence, after glancing at the mysteries of lamp-making, and noting the different merits of lamps with clockwork, and lamps with piston and weights, and after admiring the beautiful rotatory machine which gives motion to revolving lights, I go to gaze on the scientific obscurities of the "dark shed," or chamber, where Mr. James Chance presides over the final adjustment of the focus of the finished lenses and prisms, and ascertains their optical quality—a delicate and most important duty. Next we are conducted to the packing-room, where the valuable lighthouse glass is wrapped in tissue-paper and tow, and encased in stout double boxes—packing as here practised being a distinct art; to the storeroom, where innumerable prisms and lenses in both their rough and polished phases are systematically arranged in a labyrinth of passages and a museum of shelves; to the erecting-house, where the great trial of each light as a finished whole is made at night, often in the presence of leading men of science and Government authorities; such nights being gala nights for the workpeople and their families, who come thronging to admire the sunlike flash of the revolving, or the steady beam of the fixed light.

Lastly, we pass back again to the lantern-house, and, ascending the iron stairs, look from beneath the cupola of a "first-order" lantern, 30 ft. high, and 12 ft. in diameter, and, amid the ringing of hammers and busy voices of workmen, and in the spring sunlight, and on dry land, quiet and safe, try to realise its practical future—a wild rock-station, like the Eddystone or the Bishop—a black, stormy night—the

fierce dash of the waves on and over the solitary tower—the weird cry of the seabird—the lashing beat of the hail—the rushing sweep of the wind.

But the good lamp burns clear and steady, and the good lenses fill with the flame and glow thirty miles through the darkness; and securely rides the good vessel in the offing, and calmly sleep her crew, save the keen-eyed watch on her quarter-deck, to whom comes straight and unwavering that friendly and familiar beam.

All honour to the first inventor of these beautiful and beneficent lights; to the manufacturers and men of science who have perfected them; and to the Governments and Boards who have adopted them for the illumination of their coasts!

THE WAREHOUSES, ETC.

Time would fail to inspect every process of glassmaking, and so, passing through the warehouses where the mineral colours are mixed for the stained glass, and hearing that the commoner-coloured glass is made by flashing, or taking first a lump of coloured glass on the blowing-tube and over it the ordinary lump, so that the cylinder is covered on its inner side with a thin skin of blue, or amber, or ruby, or green, we reach the warehouses. Here, combined in a mile of storerooms, are the various products of the factory, two of the most important of which are glass shades, some of them of the largest size ever produced, and stacks of the pure white squares of glass used in photography. Here, too, are the "crowns" and the "sheets" in every size and quality, while the prisms stand one upon another like quoits of sizes to suit either giants or ordinary mortals. In another series are crates of those exquisitely-coloured sheets which, in hues of amber, ruby, emerald, topaz, and aquamarine, seem like slices cut from the fabled gems of some Eastern story. As a final and staggering piece of statistical information, we learn that there are 1700 workpeople employed at the Spon Lane works, and that the furnaces (besides the immense gas furnace, which is a new invention of marvellous science and utility) consume 1800 tons of fuel a week.

It has been mentioned more than once that much of the improved manufacture has been introduced from France; indeed, the very earliest glassmakers in this country were

the refugees from Lorraine, and here, amongst the "glass-house crew," bearded, blue-bloused, and with dark eyes and olive cheeks beneath their heavy, flapped, leathern hats, are a little colony of French workmen, who, with their families, occupy a row of houses adjoining the works and support a native "cabaret" of their own, where ordinaire is to be bought by the "chopine." Several of these men accumulate enough from their savings in the course of a few years to return to their native "department" in France as small farmers or landed proprietors; and their children, born in England, speaking our language, and educated at that admirable school of which we shall have to speak presently, will do more to consolidate the future interests of the two countries than a thousand treaties of mere political necessity.

On our way to visit the library we hear that there is a qualified surgeon attached to the works, who receives from each of the workpeople a very small weekly sum, in proportion to their salary. The library itself contains about 2000 books, and is attached to a large reading-room, so fitted that, while it is both warm and well ventilated, it is adapted to working men in their working clothes who may choose to spend the fragment of their dinner hour in the quiet enjoyment of their newspaper or magazine.

ORNAMENTAL WINDOWS.

Among the various departments of Messrs. Chance's works, one by no means the least interesting is that devoted to the production of ornamental window glass. In this department, under the immediate superintendence of an accomplished artist, are designed and executed windows of all sorts and sizes, in every conceivable style, ancient or modern, Grecian, Gothic, Elizabethan, Italian, and nondescript, and suited to every conceivable situation, from the bar-parlour of a beershop to the corridors of a palace—from the saloon cabin of the Pacha of Egypt's state barge to the transepts of Cork Cathedral. Here, in one room, the girls are busy brushing out the simple enamelled patterns with a brass stencil-plate and a nail-brush; there, in another, the men are tracing the outline of saint or martyr, or finishing the shadows on an archangel's wing. Here lies a group of flowers just "burnt" for the sixth time, fresh, and dewy,

and brilliant almost as Nature herself; there a landscape just begun, leaning against a huge clock-dial and three advertising lamp panes. Down stairs the "leaders" are cutting out the gorgeous-coloured glass into all varieties of quaint and seemingly unmeaning shapes, or fastening together the leaden joints of the finished painting with gas-heated soldering-irons; and down again, on the lowest level, the kilnman is watching the dull red glow on the iron covers in the kiln, and the "embosser" mysteriously wiping off the surface of the glass in cunning patterns as it lies in the broad, shallow troughs of hydrofluoric acid.

To attempt a description of all the processes conducted in this department of the works would of course be hopeless within present limits, but a brief history of the production of a stained-glass window, such as those with which the revival of Gothic art has adorned so many of our churches, will probably render most of the ordinary methods intelligible, and at the same time be more interesting to the majority of readers than the more technical details connected with other classes of work.

Let us suppose, then, that the artist has to fill a window with stained glass. The first thing to be done is to make an outline on a small scale of the stonework of the window, within which he sketches his design, indicating the colours and the general arrangement of the subject as a guide in future operations. This done, he proceeds to draw out the design exactly to the full size of the window, taking particular care to leave a broad outline for the strips of lead in which the glass will have to be fixed wherever necessary—a most important precaution, and one which, though apparently very simple, requires no little management and experience to execute well. After the full-sized drawing or "cartoon" is made, a second or "cutting"-drawing is traced from it, showing only the lines where the strips of lead are to go, and omitting all other details entirely. On this "cutting"-drawing the colours of the several pieces of glass are marked by the artist, and the glasscutter then cuts out each piece separately, laying his sheet of glass on the drawing, and following the outline with his diamond. Each piece is thus cut out of the particular colour or tint required; if the piece is to be ruby, it is cut out of ruby glass; if blue, out of blue; and so on. The colour is not put on afterwards, as it is frequently supposed to be. Each piece is

originally cut out of a sheet of glass of the requisite colour, and retains the same colour throughout. The only exception to this is in the case of yellow. Wherever a yellow "stain" is required, the glass is originally cut out of white, or slightly tinted, glass, and the "stain" is put on afterwards. Indeed, the various tints of yellow, from the palest primrose to the deepest orange-red, are the only ones that can be produced on glass without altering its surface; and the word "staining" is technically restricted exclusively to the process of imparting these tints to colourless glass. When the glasscutter has completed his portion of the work, then comes the turn of the glass-painter. The glass-painter takes the cartoon, and, laying each piece of glass separately in its proper place, he traces the outline upon it in vitrifiable colour. This process, in fact, is precisely like working on a "transparent slate," except that a brush with opaque colour is used instead of a pencil. The outlines of the drawing, after having been thus traced on the several pieces of glass, are permanently fixed by the process of "burning,"—*i. e.*, baking to a dull red heat sufficient to vitrify the opaque lines, and render them thenceforward part and parcel of the glass itself. This process is carried out either in "muffles,"—*i. e.*, ovens fitted with iron shelves which slide in and out, on which the glass is placed; or in "kilns," the glass in the latter case being placed on a carriage formed of large flat stones, and covered with an iron lid. The carriage runs into the kiln on a tramway; the doors of the kiln are shut, and the fire kept up till the glass is sufficiently "burnt." As soon as the proper heat has been obtained, a point requiring an experienced eye to determine, the kiln is "struck"—*i. e.*, the fire is put out, and the kiln allowed to cool gradually. This is a most necessary precaution, for if the carriage were to be drawn out immediately, and the glass allowed to cool suddenly, half of it would "fly" at once; and, even with every care, it not unfrequently happens that some of the pieces are found broken when the covers are lifted. After the outlines have been thus burnt on, the glass goes back to the glass-painter, who again takes the cartoon and covers it, or if large, a portion of it at a time, with a sheet of colourless glass: then lays down on it each piece of glass on which the outline has been painted, exactly in its proper place, and fastens them all together on the sheet of colourless glass

with drops of melted resin and beeswax or any other suitable substance. This done, the sheet of colourless glass, with the pieces adhering to it, is raised and placed on an easel, and the shadows of the picture are put in. This portion of the work is not traced from the cartoon, but is done by eye; and, as the glass-painter has the outline already finished to his hand, he can fill in the shades so as to correspond with those in the cartoon with great exactitude. When the shadows are quite finished, the pieces of glass are again detached from the sheet of colourless glass, and, if any yellows are required, a preparation of silver is laid on wherever requisite. The pieces are then sent a second time into the muffle or kiln; the shades are burnt on, and the yellow stain produced, the preparation of silver, which in itself is perfectly opaque, being scraped or brushed off after the "firing." If, after the second firing, more work is required on the glass, the painter repeats the process, and the glass is fired a third, fourth, or, in some peculiar instances, even a sixth or seventh time. The glass-painter's work is now complete, and the finished pieces pass into the hands of the "leader," who takes the "cutting"-drawing again, and after having laid each piece in its proper place—an operation precisely like fitting a child's puzzle together—proceeds to "lead up" the work with strips of grooved lead. The lead which he uses is of various breadths, according to the scale and style of the work, previously rolled through a vice so as to present a section like the letter H, with a groove at each side to admit the glass. This he cuts into convenient lengths and fits round the several pieces of glass. When he has joined them all together on the cutting-drawing he solders off the joints on both sides, rubs an almost liquid putty or "cement" well under the edges of the lead, and when this is hardened the window is ready to be fixed in its place. As, however, unless the window is a very small one, it would be difficult to handle in a single piece, he divides it into several pieces of a convenient size, which are fitted together when the window is fixed in its place. Bars of iron are placed across the window at the line of junction and at other convenient intervals, and ties of copper wire, previously soldered on to the leadwork of the window, are used to tie the glass to them, the sides of the glass being generally let into a groove in the stonework of the window. The sides and joints are

then finished off with a little putty or cement, and the window is complete.

Such is the whole history of a "leaded window," and, with very slight modifications, it is the history of all "mosaic" stained-glass windows of every kind, from the simplest quarry-light to the most elaborate painted window storied with scenes of legendary fable or familiar subjects drawn from Holy Writ. Up to the present time this peculiar branch of art has been almost entirely restricted to the illustration of scriptural, or at least ecclesiastical subjects; but there can be no doubt that it is to the full as suitable in many instances to secular and domestic as well as to ecclesiastical decoration; and Messrs. Chance have done well in directing their attention to the development of a popular taste in this direction. Not only in large country houses, but in almost all the mansions of our cities and towns, there are windows in hall, and lobby, and staircase, which at present either look out on views which had far better be hidden, or which are darkened by some kind of so-called ornamental glass only one degree less offensive than the outlook it is designed to hide. In all such cases the introduction of stained glass of really artistic design and execution, and suited to the architecture of the house, would clearly be a vast improvement. Indeed, while almost all the wealthier classes of the community who have any pretension to taste in art are loading their walls with expensive pictures, it is difficult to understand why they should forego the opportunity of filling their windows also with works of art surpassing any pictures on canvass in brilliancy of colour and power of effect, and certainly not necessarily inferior in design. That very few real artists have hitherto directed their attention to stained glass is unfortunately true, and is perhaps the reason why so little has yet been done towards making stained glass, like oil or water-colour painting, a household luxury; but that such artists are to be found is evidenced by the design for a hall-window which is near completion during our visit. In this design the artist has chosen for illustration the scene from the "Idylls of the King," where the jealous Guinevere has just flung the diamonds won by Sir Lancelot in the tournament which so nearly cost him his life into the river:—

And while Sir Lancelot leant, in half-disgust,
At love, life, all things, on the window-ledge,
Close underneath his eyes, and right across
Where these had fallen, slowly past the barge
Whereon the lily maid of Astolat
Lay smiling, like a star in blackest night.

The great window exhibited by Messrs. Chance in the International Exhibition representing "Robin Hood's Last Shot," shows, also, that they are quite capable of carrying into execution windows of this class on a large scale in a style fully equal to the merits of the design. Indeed, we do not remember to have seen any modern painted window which for boldness and originality of treatment and power of expression can be compared to this work of Messrs. Chance.

THE SCHOOLS.

Having finished our inspection, and proceeding towards a building which resembles a church, both in size and architectural appearance, we hear a great clamour of ringing young voices and a less clamour of a ringing bell, followed by a scraping and scurrying of little feet to the door of the said edifice. By this we know that we are near the school, and, being quickly introduced to the schoolmaster, Mr. Talbot, enter without further ceremony.

From the playground and the gymnasium the boys are flocking in—more than 250 of them, ranging from seven to fourteen years old in the upper classes, and from four to seven in another room, where we shall go presently to see the infant school. The appearance of the boys is fully equal to that of the scholars at any respectable day-school in London; and, as far as we can judge, their proficiency, especially in the matter of a clear, bold handwriting, and the ready following of dictation, superior to that of most ordinary day scholars. The education is of a plain and practical character, including drawing; and the school sustains a high character in the report of the Council of Education. There is no lack of firm but cheerful discipline, and it is evident that the work could never be accomplished successfully except under a capable and energetic master.

The girls' school, which occupies another portion of the building—or, to speak correctly, a supplementary building—

and, like the school-room attached to a church, contains above 140 girls of from seven, to thirteen, besides infants, making a total of about 500 children, who, now that Messrs. Chance have thoroughly established the school, are paid for at the rate of threepence a week—the sum thus raised, in addition to some Government aid, rendering it entirely self-supporting.

The elder girls are sewing quietly under the inspection of the governess, who tells us that it is proposed to establish a library in connection with the school, that they may have the advantage of reading on subjects likely to be useful to them in after life. We have but five minutes left of our allotted time, however, and these we have already determined to devote to the infants. Here they are, the blue-eyed, dark-eyed, fair-haired, dark-skinned, rosy, chubby rogues, a score of them, following a pupil-teacher, who falters a little at sight of a stranger in a song of four lines, embracing within its short compass four stupendous facts in natural history, with appropriate gestures. God bless them! how their little silvery voices sing out

> Cows and horses walk on four legs,
> Little children walk on two legs.
> Fishes swim in water clear,
> Birds fly upward in the air;

and at last quaver away into corners, or stop wistfully silent, or lift up a shy face here and there as we stand to look at them. Two little creatures, having fallen asleep, are put comfortably on a sort of occasional bed, upon a large bin in the corner, provided for such a common contingency. As we go out, slowly and thoughtfully pondering on all we have seen at the great glassworks, we hear the shrill notes of these little ones floating on the summer air, and feel that they are a blessed indication of England's future.

THE GLASS MANUFACTORY OF MESSRS. DEFRIES, IN HOUNDSDITCH.

BACK to London on a visit to one of the oldest neighbourhoods in the heart of the great city itself—a region which

the wayfarer has been accustomed to regard as the head-quarters of those following the mysterious business of "factors;"—where ornamental clocks, cheap foreign prints, beads, toys, tea-trays, mosaic jewellery, gold, silver, precious stones, sponges, india-rubber, walking-sticks, buttons, penny whistles, dolls, tobacco jars and pipes, combs, and "fancy goods," are but a few of the articles promiscuously heaped together in the windows, and trade flourishes without ostentatious show. To Houndsditch, by way of that gate known even in Saxon times as the Ald, or Eald gate, we wend our way direct from west to east, not without some curiosity as to the whereabouts of those workshops and show-rooms from which we know many of the decorations of palaces and public buildings have emanated.

They are not difficult to discover, for, once having reached the neighbourhood, a score of adult and juvenile fingers point, in answer to our inquiry, to a shop which, with a sufficiently handsome front, yet bears in its appearance, as many of the shops do hereabout, a disregard for external display as second in importance to the every-day work of supplying the public demand. Noticing this particular, we are not at all disappointed to discover that the interior is but one of a long range of warehouses where glass, china, porcelain, crockery, and lamps, are heaped on great counters, ranged on long dusty shelves, or await delivery in crates whose attendant straw lies in every direction. Inquiring for Mr. Defries, we are directed to the further of two counting-houses, glazed and partitioned, to reach which we have to walk so far back as to be conscious of having reached another parish. Here, too, the glass shades and lamp-globes and stray chandelier-drops (used as patterns, we suppose) lie on almost every available space, and here, answering the inquiries of a dozen people at once, and exercising an energetic supervision marvellous to behold, we discover the gentleman (one of the brothers Defries) of whom we are in search, and are delivered for a time into his hands—which are, in all probability, full enough already. With an old propensity for "beginning at the beginning," we are conducted up long flights of stairs, turning sharply up narrow passages, and entering warehouses by sudden and dimly-lighted doors, until we find we are far above the level of the street, and in a large apartment almost at the top of the range of workshops and store-rooms, where a number of genuine and primitive looms are

employed in the manufacture of lamp-cotton, a business (the nucleus of the present large establishment) which was commenced by the father of the present firm some half century ago. Here, under the superintendence of a foreman who remembers this as the staple trade of the house, lamp-cottons, both for home consumption and exportation, are made in every variety by the old-fashioned looms, wheels, and bobbins. Notwithstanding the hundred inventions in lamps, and the various means of artificial light, the "wicks" for oil-lamps are still in enormous demand, especially in India; and this branch of the business is still as prosperous as when it was commenced with the sale of a few oil-lamps by the father of the present firm, each member of which now superintends a distinct department.

Before witnessing the processes of glass and chandelier manufacture conducted on the premises, we are taken through the series of warehouses, which extend over the entire building, and lose ourselves among vast piles of lamp shades and globes arranged in racks from floor to ceiling. From these we enter a room where all the parts of the numerous patterns of chandeliers made by Messrs. Defries are kept in stock, so that any accidental breakage may be immediately remedied by applying to them for a branch or a stem, or a cut-glass "dish" or vase, according to the pattern required, and the expense of a fresh casting and cutting avoided. To railway lanterns, the coloured glass for signals and engine-lights, and a newly-invented lamp for lighting the carriages, a large space is devoted; while groves of table glass in every variety, from the costly cut and engraved service to the "wines" at half-a-crown a dozen, bewilder and perplex the mind with contemplations of the awful breakage from year to year to replace which such a stock is required. Much the same remarks apply to the wonderful array of lamps of every description and at every price, from the more costly and elegantly decorated oil-light for burning under the punkah in India to the cheapest form of paraffin-lamp; all have their representatives; while, in a large workroom adjoining, the various parts which compose them are being fitted together as they arrive from the Birmingham factory. Passing these, however, we descend to the lower warehouses, and going through the packing-room, with its great counters piled with every variety of ware, from a goblet, the cuttings of which sparkle and glow like a jewelled cup, to the five-farthing mug of a

little village child, we see one of the most interesting portions of the whole establishment in the ordinary dinner, tea, and breakfast services, with which everybody is familiar. Here in a long range of rooms in every variety of crockery in almost every pattern under the sun, from the dear old "willow" to the last elegant substitute which appeals to high-art principles. "From sixty to seventy tons of 'loose ware' is sold per week," we are informed, in answer to some inquiry about consumption. So much for quantity; with respect to price we are most concerned in inquiring about the great stacks of evidently low-priced articles which are waiting to reach their destination in poor homes. Their marvellous cheapness may be indicated by the fact that they are purchased by the dealers, who, in their turn, supply the hucksters' carts and barrows, so that the "giving away" of the trader who sells his stock by gaslight in the streets on a Saturday night is the result of two profits on the original purchase. Vast quantities of this ware, however, are exported to the colonies, and one small room is devoted to patterns, where we notice specimens of that old-fashioned burnished, copper-looking material, intended, we believe, for Africa.

In the adjoining workshops those operations are being conducted for which Messrs. Defries have attained their reputation—the manufacture of glass chandeliers and table glass, branches of the business in which the variety, both of style and cost, is still the most remarkable characteristic.

The first formation of the drops and prisms for chandeliers is effected in rooms where the lumps of "crystal" are heated in a furnace by workmen, who remove them by means of the tongs when they have acquired a plastic consistency, and, after picking out every speck or defect with a pair of shears, again reduce them to a condition in which they may be squeezed in metal moulds to the required shape: by these means uniformity of mass is secured, and the glass is free from either specks or air-bubbles. At present, however, they are the mere chrysales of prisms. Dim and roughly shaped, their many sides give out no brilliant scintillations of light, no gorgeous flecks of colour. To effect this they are carried to an upper workshop where the floor is crossed by the treadles of foot-worked lathes, and walking becomes difficult if not dangerous. Here, the rough edges having first been removed with a file, every facet is subjected by the

workman to the surface of an iron wheel which revolves beneath a continual supply of sand and water. This having removed the first roughness, a disc of Yorkshire gritstone still further completes the smoothing and brightening of the now shining facets, which only await a final application in a lathe where the wheel is of hard metal and plentifully anointed with oil and rottenstone. In the case of cut glass of every description the processes are similar, with two important exceptions: the cutting is effected by applying the glass to the circumference of the wheel; the finishing is completed by a disc of willowwood or cork. Before leaving the neighbourhood of the lower workshops, it is necessary to witness the operations of roughing globes, and that exquisite process of engraving glass, which is in itself a marvel of workmanlike skill.

The first is effected simply by fixing the globe on a lathe, where it is submitted, as it revolves, to the action of a bunch of steel wire plentifully supplied with wet sand. In this way it is thoroughly scratched until a perfect and uniform dulness is obtained; the process is then completed by being washed in a solution of muriatic acid. The engraving is neither more nor less than a triumph of manipulation, by which a workman sitting before a revolving wheel of copper, of a thickness regulated according to the fineness of the work, and supplied with oil and emery, holds the glass with more or less force against its edge, and, without any previously drawn design, grinds the frequently-elaborate pattern upon the delicate goblet or massy but brittle dish. Getting over the first astonishment that the glass is not whirled into the air. or smashed into a thousand pieces, it is an interesting sight to stand and watch the pattern grow upon the hard and glittering surface.

Ascending once more, we are introduced to the rooms where women and girls, armed with gloves and strong pliers, are "pinning" the drops—fastening together the various hanging prisms of chandeliers, whether for gas or candles—with plated wire pins. In an adjoining room they are fitting the soft but brilliant panes of coloured glass into hall-lamps. Still ascending, we may witness the construction of those ornamental devices and blazing stars which are now superseding the old ineffectual oil-lamps, and the little more effective flaring and roaring gas jets in public illuminations. The stars and wreaths before us are

formed of prisms of glass set into a groundwork of dead black, behind which a strong light protected both from wind and rain will produce a steadily-brilliant effect. These decorations are destined for the public gardens at Scarborough, and are of suitably-elegant design. But we are impatient to see one of the superb and immense chandeliers which are, we understand, being put together previous to their being despatched to St. Petersburg, there to illuminate the Grand Opera House and new Theatre. For this purpose we are taken into a room which has some remote resemblance to a belfry, inasmuch as the ceiling is cut away to allow sufficient height for the enormous structures of glass continually being put together there. The combination of exquisite prismatic forms with arabesques, and pillars, and vases, whose diamond facets seem lambent even in the waning sunlight, hangs in such a space that, except for its lightness and freedom of outline, we should be compelled to use the words "bulk" or "mass." Neither of these terms will apply, however, to an object which, all transparent, is even now quivering into a score of broken rainbows and dyeing that grim workshop with prismatic hues as it awaits the experimental lighting up with gas. This chandelier will certainly take nothing from the reputation which the Messrs. Defries have already acquired as gasfitters and gas-engineers in their fulfilment of Government contracts, and in lighting our own Opera House in Covent Garden, as well as numerous theatres and many other public buildings throughout the country.

Entering the show rooms, we fancy for a moment that we are penetrating a stalactite cavern, from whose ceiling hang crystals in every variety of shape and size, shimmering in gorgeous tints, and flecking windows and floor with rainbow dyes. Here hang a series of long, sharply-cut prisms like northern icicles, brilliant in impenetrable frost; there loop out festoons of diamond-drops sparkling like the network hanging on winter trees. In stars and goblets, and flashing spires and opal moons, the prismatic fires seem to burn and glow amidst a glitter of pure white, and even without artificial light to throw into strong relief, the ornamental clocks and parian vases, the statuettes, and china and porcelain, which crowd the tables beneath.

But we have yet to see the showroom for table-glass and china, and it is already dusk—so late, indeed, that the work-

people have already gone home, and little time or space is left for a description of the many beautiful objects in glass and china, which are placed there more for the convenience of choice and inspection than with any effort to exhibit them to their best advantage.

Exquisitely-engraved glass jugs, claret-cups, and tankards of classical design, glasses delicately tinted in amber, ruby, and pale emerald; crystal goblets, studded with coloured bosses, which gleam gemlike; household class of good, honest patterns, brilliant utilities to be bought for shillings instead of pounds, occupy one half of the long room. In the other, vases of exquisite workmanship, jars, jugs bowls, and tea, coffee, and dinner services in number almost too great for unembarrassed choice,

We notice here, first, that beautiful eggshell china, much of which bears, like the glasses just mentioned, only the one delicate tint of amber, green, or ruby, outside, contrasting daintily with the interior of pure white; and, secondly, those marvellous Eastern coffee-cups, like children's tiny mugs set in small, deep saucers. These cups of so many brilliant hues are embossed with such a rich profusion of bird, and butterfly, and flower, that it is no wonder the wealthy Turks and "caftaned," brown-skinned natives of Mogadore come here by the dozen. In such cups the very weakest infusion would smack of "Araby the Blest," and even the regulation cocoa of a London workhouse acquire richness and flavour.

PROVISION AND SUPPLY WORKSHOPS.

Price's Patent Candle Company, Sherwood Works, Battersea.—Visit to The Lambeth Marsh Candle Works.—Visit to a Wax Vesta and Lucifer Match Factory.—The Bathgate Paraffin Oil Works.—Visit to a Provision, Cigar, and Wholesale Grocery Establishment.—Visit to a Tobacco Manufactory.—Paper Bags.—Mustard and Starch, a Day at the Carron Works, Norwich.—Worcester Vinegar, Messrs. Hill, Evans, and Co.'s Vinegar Works, at Worcester.—Burton Bitter Beer, Messrs. Allsopp's Pale Ale Brewery, Burton-on-Trent.

PROVISION AND SUPPLY WORKSHOPS.

PRICE'S PATENT CANDLE COMPANY, SHERWOOD WORKS, BATTERSEA.

Twenty years ago there stood on the banks of the Thames at Battersea a beautiful terraced garden, where the "first gentleman in Europe," to whom we owe the invention of the Brighton Pavilion and white kid smallclothes, used formerly to walk with Mrs. Fitzherbert.

The site of this charming retreat is now more usefully occupied by a factory, which covers some twelve acres of ground, has cost £200,000 for buildings and machinery, employs more than 800 workpeople, from amongst whom a full and efficient company of rifle volunteers is formed, and which has established a mercantile branch at Vauxhall, and a companion workshop at Bromborough, near Birkenhead.

Having become acquainted with these particulars, we are scarcely surprised to learn that the name, Price's Candle Company, has little direct reference to any individual of the name of Price, but arose out of a combination of circumstances, originating in the fact that the father of the present manager (Mr. Wilson) and his partner adopted the name of E. Price and Co. as a trading firm, who sold their business to the present joint-stock association in 1847.

While pursuing the way along the broad but irregular street leading from the Wandsworth Station, we learn also, from a lecture delivered before the Society of Arts by the present managing director, Mr. G. F. Wilson, that the busi-

ness of this enormous English workshop had so increased during the first fifteen years, that whereas in 1840 eighty-four hands were employed to produce the monthly quantity of 22 tons of cocoanut, stearic, and composite candles, valued at £1590, in 1855, 2289 hands manufactured 707 tons of stearic and composite candles and night-lights, worth £79,500 per month. To these results the recent improvements, under the continued management of Messrs. G. F. and J. P. Wilson, have still made considerable addition; and, despite the oppressive heat and dust of a July day, we trudge along the roadway, not without interest in the various processes to which we are to be conducted under the guidance of the first-named gentleman.

It is nearly two o'clock when we reach the long high wall flanking the works on the side of the road, and already knots of workmen and a troop of boys in white canvas frocks and linen caps are strolling towards the gate after the dinner hour. From the lodge where we report ourselves, a messenger is despatched to announce our arrival, and, following him to the counting-house at some distance, we are at once introduced to Mr. Wilson, and commence so much of our tour of inspection as can be accomplished in a summer's afternoon. On a great open wharf upon the river's bank, whence we can see the trees and meadows of the open country on the other side, lie scores of casks, the contents of which we know to be palm oil, not only from its bright yellow colour, but from the peculiar and not unpleasant odour. In following this oil through the various processes necessary for converting it into candles, soap, and glycerine, we shall witness the most important operations at the Sherwood Factory, since palm oil is here the staple representative of all other vegetable or animal fats—the mineral oils demanding a separate treatment, to be afterwards noticed. From Accra, on the western coast of Africa, from Whydah, from Lagos, on the Guinea Gulf, and from Bonny, where the natives, however uncivilised, no longer barter their commodities for glass beads and yellow crockery, but demand a full commercial equivalent, these casks reach the wharf at Sherwood, where they are almost immediately rolled to an enormous shed, there to be emptied through metal-edged openings in the floor into a great underground tank, each cask being thoroughly cleaned of its contents by means of a jet of steam. From this tank the oil is pumped by steam power to the various buildings

where it may be required, but principally to the cauldrons, where it is treated with sulphuric acid at a certain temperature until it becomes chemically hardened into a brown mass, the colour being principally due to the carbonizing influence of the acid upon some of its constituents.

By these means the glycerine is decomposed, the sulphurous acid gas driven off, and the fat changed to a mixture of fat acids. Following this after some of the charred material has been washed off, we discover in the warm and somewhat greasy atmosphere of another building a series of stills, the pipes representing the worms of which contain heated steam. Here the black fatty substance is reduced to a brownish liquid, which runs into the pans placed to receive it freed from most of its impurities, and separated from the glycerine which is distilled over it by the action of the hot steam. In an open shed which stands on the water's edge at another part of the works, and where the "thorough draft" causes us instinctively to button our coats and hold our hats on, a complete perspective of racks somewhat resembling gigantic timber-built crates standing on end, are filled with shallow, oblong, square tin dishes, in which this brown oil from the first distillation is placed to cool into long flat cakes. It so much resembles Everton toffee in the well-known tins, that we are almost induced to taste it, but are led away at once to the "press-room," to which the cakes are conveyed on trucks, having previously been placed, by an ingenious apparatus, between mats of cocoanut fibre. These oleaginous sandwiches are then placed one above another in powerful hydraulic presses, and the oleic acid, being squeezed out, runs into the pans beneath; while the stearic acid remains in a thinner, harder, wax-white slab, semi-transparent, and with the marks of the mat upon its surface, giving it the appearance of a passover cake not quite enough baked. These almost white slabs are again subjected to pressure in a room so heated as to squeeze out their remaining impurities, and are finally melted in a large building filled with deep wooden vats, into each of which a long coil of pipe introduces a jet of steam sufficient to liquefy the hardened mass of stearine, which is thence conveyed from a large wooden reservoir direct to the candle-room.

Entering this room, which is 160 ft. long by 104 wide, and ascending by a flight of steps to a glazed office or watch-tower occupying an elevated space at one end, we seem to be

looking down at a novel and curious bakery. We are induced to this reflection, however, only by the general whiteness of the dresses of the boys employed there, by the warm atmosphere, and the long trough-like tables extending throughout the apartment. These long tables, however, are the benches containing the candle moulds, and along the top of each bench a railway carries the "filler," a large can holding the melted material which has been supplied from the reservoir just mentioned. Every bench is superintended by a man, the operations being conducted entirely by boys, each of whom attends to several moulds. Watching the process, we discover that the cotton wicks are wound upon reels which lie (one for each candle) near the bed of the machine. The end of the cotton is drawn through the moulds (the pointed ends forming the top of the candle being downwards), and secured in its position at the top (which is the bottom of the candle) by means of a brass split-ring, which keeps it tight and prevents its slipping through: the moulds are adjusted, the filler is brought on and charges them, and the candle is formed. When a number of moulds are cool the candles are discharged by a most ingenious adaptation of compressed air, which is drawn from an iron boiler by means of a pump, and conveyed to the moulds by means of a pipe and a series of taps; the instant this tap is turned, the air, which exercises a pressure of about 45 lbs. to the square inch, shoots the candle from the mould with a noise like the first hiss of a rocket, and it is caught uninjured by the boy in attendance, its brilliant surface and almost transparent substance exquisitely clean and pure.

The difficulty of preserving the uniform weight of the candles, so that they may always represent so many to a pound, is overcome by an ingenious plan; and, indeed, the company were for a short time sufferers by the importation of foreign candles, which were sold in *boxes* weighing only 13 oz. instead of the full pound, which their own boxes contained. They obviated this, however, by issuing *full pound* boxes, and, at a smaller price, *reputed pound boxes*, with the distinction printed outside the wrapper—a course which, we are told, abated the inconvenient practice. The difference between the specific gravities of fats and oils, however, and the variety of weights in the several quantities of candles, make it necessary to adjust them after they come out of the moulds; and to effect this, almost all the candles are made

with an inch or so to spare in their length, and the weight balanced by removing the superfluous portions with a circular saw. All day long the candles are shot from the moulds by hundreds, ordinarily at the rate of 100 tons a week.

The entire range of enormous workshops and warehouses at Sherwood are provided with arched roofs of corrugated iron, partly lighted from the top. The effect of this is that they are surprisingly lofty and well ventilated, while the warehouses are so cool that we feel a grateful relief in following the candles from the moulds to a vast storehouse, or rather a Siamese twin of a storehouse, with a double roof and a communicating party brick wall. Here, in great boxes like sea-chests, the delicate white cylinders lie, safe from dust and heat, awaiting their final destination. But we have yet to see the shops where the ornamental boxes and wrappers are formed—a part of the factory which is not the least interesting as involving the solution of an old difficulty of ours as to how the combination of thin wood and thin paper could be made to produce a strong envelope for even heavy materials.

Here, then, the broad deals are brought in from the timber-yard, where goodly piles of them lie stacked, and one of them having been selected, we see it placed in a long and terrible machine, where the plane carves from it with unerring accuracy a strip of its entire length and breadth no thicker than a piece of brown paper, 100th of an inch, indeed. This, having been damped, and receiving over one surface a coating of thin paper, securely pasted, is consigned to another engine, where knives, exquisitely adjusted, and in proportion to the size of the boxes required, cut through portions of the wood (but without dividing the paper), in the shape of a box, with sides and ends flattened out; a bundle of these squares, containing the cut portions, are handed to a man who removes the superfluous corners by a dexterous twist, and leaves the box shape easily bent, and to be re-covered ultimately with attractive pictures or highly-coloured paper. The repeal of the paper duty makes a difference to the company of £3000 a year, an amount almost exactly balanced by the increased price of cotton for wicks since the American crisis. But the afternoon is already far spent, and the train is due at 6.30. At the door of an adjoining building a man waits with key, and we are invited to inspect the baths. Once more referring to the candle moulds, it is necessary to

mention that along the bed of the bench in which they are placed there runs a channel, through which warm water flows constantly, keeping them at a proper temperature to receive the charge. This water, perfectly clean, since it touches only the outside of the smooth metal moulds, is admirably utilised, indeed; for Mr. J. P. Wilson, the brother of our informant, has at his own expense built a large swimming bath, well provided with dressing-boxes, and capable of admitting forty bathers at a time. Here, on separate evenings of the week, and at certain hours, men and boys may have a luxurious swim in a running stream of tepid water, and at the same time ordinary warm baths are provided in a separate department for those who prefer them.

From the baths we have scarcely time to bestow more than a few minutes to the training-schools attached to the factory, where the boys receive an amount of education sufficient to enable them to become intelligent and often trustworthy workmen. Indeed, the whole system is as much as possible one of progressive encouragement, and the more intelligent and appreciative both of the boys and men are advanced to situations suited to their particular capacities, and become tradesmen, such as coopers, tinmen, engineers, carpenters, &c., so that many of them remain for years in the service of the company, and changes amongst the hands are not very frequent. A system of co-operation, too, has been organized amongst some of the workmen, who have become shareholders in a society for providing workmen's stores, on the principle of mutual advantage. These stores, which furnish bread, meat, tea, coffee, and other articles of general consumption, are in no way connected with the principals of the company, but occupy a neat shop in the main street, where ham, eggs, tea, sugar, &c., occupy the front, and a clean, comfortable-looking bakehouse is built at the rear of the premises. For the convenience of the employés a large room, similar in appearance to the other buildings, is devoted to supplying dinners and teas on the works. Here a cook, appointed and paid, we believe, by the society, attends to furnish the meals, the company finding the building, as well as light and firing. Joints of meat dispensed at "per plate," vegetables, bread, cheese, and butter, are sold at a small profit to those of the workmen who choose to avail themselves of the convenience, the only claim made by the company on behalf of those who require very cheap refreshment being, that a

thick slice of bread-and-butter and a pint of tea shall be supplied for a penny, and that any workman taking his own daily allowance of food shall have it cooked for him free of charge.

This, however, is a privilege seldom claimed, since the meals provided by the cook are both better and cheaper than those which could well be bought separately. It is not easy to over-estimate the benefits of this arrangement for men and boys living at a distance. There is no real necessity for frequenting the public-house at meal times; and the boys especially seem to enjoy their mug of hot tea with a sincere appreciation, which is certainly not diminished by the small outlay it involves. Most of the departments, too, are at work night and day; and it must be a blessing to be able in the cold gray of the winter mornings, or the hot, sultry summer nights, to obtain at little cost wholesome meat and drink, in a comfortable room amply provided with benches and tables. That the joint-stock company is prosperous is indicated by the fact that, after paying interest on the capital for the last six months before our visit, there remained to be divided as profits amongst the members £182 6s. 0½d.

Passing quickly through the enormous cooperage, which when cleared makes an admirable drilling-room for the rifle corps, and the various forges, furnaces, and toolshops, where copper pans, cisterns, wheels, parts of machinery, and most of the metal-work used on the establishment are manufactured and repaired, we reach another portion of the wharfage or river front, where barrels and iron cisterns contain large quantities of petroleum; not the description of rock oil now so largely imported from America, and of great volatility, but that more dense description known as earth oil or Rangoon tar.

In a large building adjoining the wharf this oil is consigned to an enormous still, holding sixteen tuns, where the more volatile portions come over at different temperatures, ranging from 160° to 620° Fahr. The first and most volatile of these is a sort of benzoin, known as sherwoodole, and, like benzoin, used for cleaning various fabrics from grease; the next is the well-known Belmontine oil, a pure description of paraffin, without colour and almost without smell, admirably adapted for superior lighting purposes. Then come the light and heavy machinery oils,

refined according to the class of engines to which they are to be applied, and admirably adapted, by long and carefully-noted experiments, to the lubrication of spindles at a much cheaper rate than the oils formerly used for that purpose. Last of all, the distillation produces the beautiful white, solid substance known as belmontine—a sort of paraffin, from which is made those elegant and translucent candles which have now become so well known.

But we have all this time been neglecting one of the most important of all the products of this interesting place—one, too, which is only just taking its rightful place as a remedial agent, many of whose uses have still to be sought by further experiment. Early in the afternoon we have seen the glycerine separated from the fatty acids of the palm oil and distilled to a clear tawnyish fluid. We must now rapidly follow it to completion as the pure glycerine, the production of which eminently belongs to the Sherwood Works.

This substance, which was formerly turned into charcoal by the action of sulphuric acid, and which was considered as mere refuse—its presence in the candle, indeed, being the cause of the offensive smell of the half-extinguished or smouldering snuff—is now distilled, as we have seen, over the fat acids, and carefully preserved. Besides its composition with other materials into that beautiful and emollient soap of which such large quantities are supplied by the company, it is redistilled to perfect whiteness, and afterwards tested separately for every probable impurity. The result is a fine, rather viscous fluid, with a faint but agreeable smell, and a flavour not unlike a combination of noyeau and guava jelly, but with a peculiar pungency of its own. Here in the laboratory we see it being tested in tubes, stored in great bottles of blue glass, or confined in smaller stoppered, capsuled phials ready for sale; and while listening to its history, test its virtues, not in a bumper, but in a sweet and palatable globule. There is no doubt, however, that this history is only at its commencement, since it is constantly being applied to new purposes, both in medical and natural science. Its healing properties, when applied to burns, scalds, chapped hands, and several skin diseases, are already well known; but it has also been used with success in certain stages of confluent smallpox in order to mitigate the eruption; and recent cases attest its value in diseases of the ear, and as an internal remedy for disease of the mucous

membrane, as well as either a substitute or a vehicle for cod-liver oil. One valuable property of this substance is its efficacy as a solvent in combination with other medicines, particularly preparations of iron; as an ingredient in pomade or hairwash it is valuable for its property of removing scurf or dandriff; and it has been largely used for scientific purposes, both in preserving objects of natural history, especially fish, and in preparing objects for the microscope. Even since our visit glycerine has been prominently mentioned by Professor Béchamp, of Montpellier, as one of the substances characterising the analysis of sound wine, but not to be discovered in wines the quality of which is much deteriorated. There doubtless remains for this extraordinary substance, which is said on high medical authority to be as harmless as pure sugar, a future interest which will, it is to be hoped, be inseparable from the works where it has been brought to its present perfection.

VISIT TO THE LAMBETH MARSH CANDLE WORKS.

The manufacture of candles of every kind and description, and of almost every conceivable light-giving material, is one of the branches of industry in which London more particularly excels. The London wax-candles have always been considered superior to most others; the composite and stearine now compete successfully with the best produce of the celebrated works in the Rhine provinces and other parts of Germany; the spermaceti are equal, if not superior, to the renowned Pennsylvanian; and the paraffin are altogether unrivalled.

We recently had occasion to visit the extensive wax, stearine, and paraffin candle-works of Messrs. J. C. and J. Field, at Lambeth Marsh, which having now been in existence for nearly two centuries, may fairly claim a conspicuous position among our very oldest business houses. We were most courteously received and conducted over every part of the establishment by one of the Messrs. Field, in whom we had the good fortune to find a competent and obliging

guide. The premises comprise extensive cellars and warehouses, filled with immense stores of paraffin from Bog-head coal, wax, spermaceti, tallow, and other animal fats, palm oil, &c.

Two steam-engines and four boilers, in a large, conveniently situated and commodiously arranged boiler-house, supply the necessary power for the multifarious operations carried on on the premises. One of the engines is of 30 horse-power, and has a small donkey-engine appropriated to its service for supplying it with water. The other, of 10 horse-power, is more specially employed in working the hydraulic pumps for the press-rooms. By an ingenious contrivance, designed by Mr. Edward Field, C.E., the pumps may, by means of communicating rods, be detached and set to work again in an instant with the greatest ease by the attendants in the press-rooms, at several hundred feet distance from the spot, avoiding thus all confusion and running from place to place.

For the manufacture of their stearine candles, Messrs. Field use a mixture of tallow and palm oil. It is pretty universally known now that tallow and other fats and oils may, by boiling with alkalies or alkaline earth, decomposing the soap by means of an acid, and subjecting the fatty mass to great pressure, be divided into two distinct portions—a liquid oil, which is termed *elaine* or *olein*, and a hard white solid, consisting of a mixture of stearic and margaric acids, and admirably suited for the manufacture of candles vastly superior to the tallow dips and moulds of former days.

The process of saponification is effected here in the so-called "saponifying-house." Messrs. Field still continue to carry out the old process, as originally recommended by Chevreul, which yields a purer and harder stearic acid than is to be obtained by the more modern plan of distillation. The fatty mass of tallow and palm oil is mixed with 15 or 16 per cent. of lime, in the form of milk of lime, in large iron vats, holding about ten tons each. The mixture is boiled in the vats with free steam, which converts it into a hard and insoluble lime soap. This is removed from the saponifying vats into lead-lined vats, where it is treated with sulphuric acid, which decomposes the lime soap, forming sulphate of lime with the alkaline earth, and liberating thus the stearic and margaric acids. The liquor in the saponifying vats contains *glycerine*, or the sweet principle of oil, another valuable

constituent of fixed fats and oils, which is turned to proper account for other purposes. The mixed acids form a mass of a deep-brown colour, which is first washed with water, or *refined*, as it is technically termed, then drawn from the refiners, in the liquid state, into the tin-plate trays, called *caking-trays*, in another part of the premises known as the caking-room. These trays are about two feet long, by ten inches wide, and one inch deep; there are thousands of them in the caking-room, placed on suitable racks. In these trays the liquid mass is allowed to cool, and solidify very slowly, to ensure the most perfect crystallization, which is absolutely indispensable to the success of the subsequent operation of the expression and removal of the olein from the mass; since a less gradual cooling would be sure to lead to imperfect crystallization, and the amorphous portion of the mass would so firmly retain the enclosed olein as to defy the strongest pressure. The cakes obtained by this process are of a lightish-brown colour and crystalline structure; they are, of course, very greasy to the touch. They are now taken from the caking-room to the cold press-room, where they are piled up in double columns, with mats and tin plates between every two of them, and subjected to enormous hydraulic pressure, worked, as has already been mentioned, by the pumps in the boiler-house. At the time of our visit the pressure was actually 340 tons, as registered by Hawkins's pressure scale. It will readily be conceived, then, that the oily liquid, or olein, runs pretty freely from the cakes; it is collected in suitable tanks beneath.

The cake of mixed acids, which, for shortness' sake, we will henceforth call here simply stearic acid, comes from the press nearly white and hard, and reduced more than half in size. The operations of the press also require great skill and caution, as the oily liquid must be extracted very gradually only; the sudden application of high pressure would simply destroy the crystallization of the mass, and would thus altogether fail to answer the intended purpose.

The cakes are now taken to the cold press cake-refining house, where they are boiled down again with free steam, after the addition of a small quantity of sulphuric acid, to remove the last traces of lime. After this operation the cakes are taken to the hot press-room, and inserted in serge bags, each of which is placed between two thick horsehair mats, joined together at the bottom, like a book; these again

are placed between wrought-iron plates, and subjected to horizontal pressure in a cast-iron press, keyed with strong wrought-iron side bars, and with hollow sides for the application of heat, and receiver beneath. This operation serves to remove the last portions of olein, the stearic acid being now left perfectly white and hard, and sufficiently pure for all practical purposes.

The olein in the receiver of the press-rooms contains a not inconsiderable admixture of stearic acid, which Messrs. Field hold much too valuable to be allowed to go to the soap copper. The oily liquid, therefore, is lifted by steam power from the receiver into tanks, and thence conveyed by a pump into calico bags eight feet long by two feet broad, and one inch in width, placed in a press in another department of *the premises, called the "oil-press room," and confined* there by suitable arrangements. The pressure applied is about 100 lbs. to the square inch; the olein percolates freely through the bags; the stearic acid remains deposited on the inside. From 10 to 12 per cent. of solid material is thus obtained, yielding about 60 per cent. of pure stearic acid. This raises the total amount of stearic acid obtained from the original mixture of tallow and palm oil to somewhere about 50 per cent.

The white hard stearine cakes, which are now sufficiently pure for all practical purposes, are taken to the moulding-room, a spacious compartment containing a number of Stainthorp and Co.'s patent candle machines, and several pans strongly silver-plated inside, and suitably disposed for melting purposes. Each of these pans holds about three cwts. of material. The stearine cakes are broken into pieces, and melted in the pans. The melted mass is taken in tin cans to the candle machines. These consist of longitudinal cast-iron tanks, filled with water, and with a trough running on each side. The wicks are continuous, being wound round spools or bobbins. Each tank moulds 16 lbs. of candles at a time (of various sizes, as may be required), which are forced up through the trough by levers, and allowed to cool, after which a fresh supply is poured in for the next moulding, the wicks are cut, and the first series of candles removed.

The spermaceti candles, for which the firm of Messrs. Field is deservedly celebrated, are made, in a separate department, by the old process, vastly improved, however, of

late years. The candles made now at their works are incomparably superior to what the firm used to produce some years ago. One of the greatest improvements is the use of plaited wicks, first introduced by a late partner in the firm, Mr. John Field, jun.

The wax candle department claims our attention next. This is the oldest branch of the factory. The candles are made of bleached wax, with plaited wicks, and after the old fashion, entirely by hand. About forty wicks are suspended by strings from hoops, which again are suspended over capacious pans filled with melted wax. The wax is poured along the wicks with a ladle. As the wax gets colder as it reaches the end of the wick, it has a tendency to collect there in larger lumps. To counteract this, the wick is occasionally reversed. When the candles have attained the required thickness, they are removed from the hoop, and rolled into the proper cylindrical shape on marble slabs, with heavy boards made of lignum vitæ or mahogany, twenty inches long by fourteen wide, and one inch thick. The slab is wetted with water, to prevent the wax sticking to it or to the board. The tops are finished by means of a fluted board. The coloured wax candles made here are tinted only partially through, as they would not burn if coloured right through.

In the so-called *taper room*, bougies and wicks are made by a process somewhat resembling wire-drawing. A double cotton wick is drawn through a bath of melted wax at one end of the room, made to pass through a perforated iron plate with cylindrical holes graduated to the thickness required, and wound on a drum at the other end of the room. These articles are made, not by the yard, but actually by the mile, to the tune of some ten or twelve miles of bougies and thirty miles of wicks per week!

The whole of the wax consumed in the establishment for manufacturing purposes, comes from the firm's wax bleaching works at West Moulsey, Surrey, most probably the largest wax bleaching works in England.

Our limited space compels us to dismiss, with a mere passing allusion, the wax night-lights, which this firm first introduced into England, sealing-wax, scented soap, and many other articles made at these works. For their "United Service Soap Tablets," Messrs. Field have gained great and deserved celebrity.

We now finally come to an article in which the firm of

Messrs. Field may justly claim the first place among English manufacturers—paraffin candles. Having been engaged since 1851 in the production and refining of this material, they in 1857 succeeded in presenting to the public the first paraffin candles made in England, and have since maintained indisputably the position thus attained in this branch of the candle trade.

Paraffin, or *Tar-oil Stearine*, is one of the multitudinous products of the distillation of coal-tar. It was discovered first by Reichenbach. The extraordinary name which it bears is derived from two Latin words, *parum affinis*, which are meant to express that it has little or no affinity for other substances, the most energetic chemical re-agents, as strong acids, alkalies, chlorine, &c., failing to exercise the smallest action upon it. Oil of vitriol, for instance, which will speedily convert wax, spermaceti, stearic acid, &c., into a blackened mass, leaves paraffin entirely unaltered at ordinary temperatures. This affords an excellent means of detecting adulterations in paraffin candles. It is known, for instance, that stearine is occasionally used in the manufacture of paraffin candles: this debasement of the article may at once be detected by subjecting a small sample of the mass to the action of concentrated sulphuric acid, when the least blackening will afford a sure proof of adulteration.

Paraffin contains only carbon and hydrogen, in the same proportion as in olefiant gas. It is derived by the action of heat upon many organic bodies, but on a large scale, for practical purposes chiefly, from a species of mineral coal, commonly known as boghead coal, or Torbane Hill mineral. A description of the process employed for its extraction would scarcely be necessary. Suffice it to say, that the process is one of distillation, requiring, however, the most careful and delicate management of the heat applied.

To give some notion of the importance of the operations carried on at Messrs. Field's Paraffin Works, we may just mention that the cost of the raw material consumed in the manufacture is considerably in excess of the cost of wax and spermaceti combined, extensive as those branches of the business are. We believe that Messrs. Field have at present a Government contract for a large supply of paraffin candles. On the occasion of our visit we saw an immense store of large paraffin blocks, perfectly white, glossy, and transparent, and void of all taste and smell.

The candles made of this material are incomparably superior in illuminating power to all others. The light produced by 98lbs. of paraffin candles is equal to that of 120lbs. of spermaceti, 138lbs. of wax, 144lbs. of stearine, or 155lbs. of the best composite candles.

Plaited wicks are used, of course, for all paraffin candles made at these works. There is a separate department, called the "tinting-room," where paraffin candles are coloured right through with the most beautiful and delicate tints supplied by aniline,—another of the multitudinous products of coal-tar. Owing to the transparency of paraffin, the proportion of colouring matter required is so small as not in the least to interfere with the illuminating power of the candle.

Each paraffin candle made at Messrs. Field's works is stamped, at the lower end, with the name and address of the firm in full, and the Exhibition prize medals awarded to them.

We lastly paid a visit to the cotton stores, where we saw a goodly number of bales of the best cotton, used for the manufacture of wicks. We were informed that the present rise in the price of cotton is a very serious item in the manufacturing cost of candles, and may, indeed, ultimately lead to a rise in the price of the latter.

We cannot conclude this notice without expressing our admiration at the excellent arrangements made by the firm for securing the greatest cleanliness and most perfect ventilation in every department of the works, and the thoroughly intelligent and philosophical manner in which all the processes and operations are carried on.

VISIT TO A WAX VESTA AND LUCIFER MATCH FACTORY.

The original process, by which man first succeeded in producing fire, consisted in rubbing two pieces of dry wood together. This process, which is, however, still in use among many savage tribes, was speedily superseded, in the first period of civilisation, by the revolving wooden disk and cylinder, and this, again, by other and improved methods,

until the tinder-box was introduced, with its flint and steel, and brimstone match. This venerable antique kept its ground for ages, and the time is still within the memory of many living men when it constituted our most approved means of obtaining fire. However, when, with the new era of chemistry, so many and such glorious discoveries followed each other in rapid succession, to be applied with the same marvellous rapidity to the arts of life, the "manufacture of instantaneous light," as it has not unaptly been termed, also made a gigantic bound forward, and the so-called *Briquets phosphoriques*, or inflammable match-phials, made their appearance some forty odd years since. These consisted of a small phial of glass or lead, either with a bit of phosphorus inside, slightly oxidized by stirring it round with a red-hot iron wire, or filled with a mixture of cork-raspings, wax, petroleum, and phosphorus, incorporated by fusion. The phosphorus, or the mixture in the phial, served to kindle sulphur matches dipped into it. The so-called oxygenated matches were an improvement upon the *Briquets phosphoriques*. These matches consisted of splints, either tipped with sulphur or not, which were dipped in a paste, made of a mixture of pulverized chlorate of potass, flowers of sulphur, sugar, and gum arabic, with water, and were then kept in a warm place till they were thoroughly dry. To kindle one of these matches, it was dipped into a small well-stoppered phial with strong sulphuric acid in it, thickened with asbestos. These were the great improvements which more immediately preceded the invention of the friction or instantaneous light match, which, by dispensing altogether with the phial, made the process of striking a light one of extreme simplicity. Mollet's pump for kindling tinder, touchwood, &c., by compression of air, and the so-called electric lamps, were rather interesting as physical apparatus than useful for practical purposes; and Döbereiner's platinum apparatus, though a very neat and elegant instrument, was rather too dear for popular uses. Moreover, all these are now completely superseded by the instantaneous light match at present in almost universal use, which we lately saw manufactured in its most improved and most perfect form, on the occasion of a visit to Messrs. R. Letchford and Co.'s factory in Bethnal Green.

The manufacture of lucifer matches is generally associated in the minds of men with some wretched hovel in the pur-

lieus of Whitechapel, or some other equally distinguished locality, where a few miserable boys and girls are being slowly but surely poisoned to death by the fumes of sulphur and phosphorus.—That there are, unfortunately, still a few of these "congreve or lucifer manufactures" in existence, is simply owing to the authorities grossly and culpably neglecting to put in force the wise provision of the law, which requires every match factory to keep at fifty feet clear distance from any inhabited dwelling. The evil, however, is rapidly dying out, as matches can now only be profitably made in very large quantities.

Some twelve years back, when Mr. R. Letchford entered the match trade, he found that the supply of matches in this country was almost entirely in the hands of foreign makers. The matches of English manufacture were of the most common kind, with the exception of about twenty-five per cent. that might be considered of respectable quality. Mr. Letchford, being a practical chemist, and enjoying, in this respect, a vast advantage over most British congreve makers, set at once about reforming this unsatisfactory state of things. His damp-proof matches, carefully dipped and warranted to light every one of them, were speedily appreciated by the trade as a very superior article, although a trifle dearer than the matches supplied by other makers, who soon found it expedient to imitate the example set them. At that time, the import duty on foreign matches was 4d. per gross boxes of 100, and the sale of the foreign article was beginning to flag. The reformed tariff, however, having reduced the duty to 2d. per gross boxes of any size, we were suddenly inundated again with a truly astonishing quantity of round boxes, with 500 matches in them for 1d.! But the public soon discovered the worthlessness of this new importation—hardly one out of ten of these matches would light. When the free tariff came, the struggle was pretty nigh over, and the superiority of the English match over its foreign competitor was firmly established; the last blow against foreign competition in this branch of manufacturing industry being dealt, again by Messrs. Letchford, through introducing their patent matches saturated with paraffin, instead of the usual brimstone coating. This is truly one of the greatest improvements introduced into the business. The paraffin dipped match ignites from the lighting composition with the greatest readiness, and burns freely, with a

beautiful clear flame, and without the least smell—very different, indeed, from the objectionable smell and the choking fumes of the old brimstone match, which is now only made by Messrs. Letchford to supply the demands of those who prefer the old to the new and improved, although no difference is made in the price. However, there is no accounting for tastes.

Among the very largest factories of matches in the world, the establishment which we are now about to describe occupies a most conspicuous, if not, indeed, the principal and foremost place, not even excepting the world-renowned match works of Pollak, at Vienna, and Bernhard Fürth, at Schüttenhofen, in Bohemia.

The premises, which, to give some notion of the magnitude of the works, cover an area of very near two acres of ground, were erected, some few years back, upon a plan devised by Mr. R. Letchford, and based upon the principle of the most perfect division of labour, as well as upon the principle of the greatest attainable safety to the lives and health of the people employed in the business. They are, in every respect, admirably suited for the intended purpose. They consist chiefly of two enormous buildings, opposite each other, with a large courtyard between. In the one building are carried on the operations of cutting, slitting, planing, and preparing the wood for the boxes; in the other, the wax vesta lights and the matches, &c., are made. On the occasion of our visit, we had the very great advantage of Mr. R. Letchford's own kind guidance, and of the lucid explanations of the manager of the works, Mr. Morris.

We were first taken to the waxing floor, where the taper for the vesta lights is prepared, by drawing the cotton wick through a bath of melted wax. The process very much resembles that described in our visit to the Lambeth Marsh Candle Works, with this great difference, however, that the vesta taper has to be drawn over and over again through the wax bath, until it has acquired the desired thickness, cylindrical form, and perfect finish. The wax is melted in a water-bath, heated to the proper degree by gas-burners placed beneath. The regulation of the proper degree of heat to be given (between 140° and 160°) requires nice management. If the heat is too strong, or the temperature of the several wax-baths differs, the tape presents wavy lines and inequalities, which is objectionable. When

perfect, the taper looks like the finest silk tresses. When the manager of the works has inspected and passed the taper, it is cut into lengths of twelve feet, which are taken in bundles to the entrance end of this upstairs wax compartment, where a woman (all the workers in the wax department are females) cuts it, in an appropriate cutting-machine, into the required lengths of one, one and a half, or two inches, which fall into a box beneath. When the box is full, it is placed aside by the cutter, and an empty one substituted for it. At the ringing of a bell in the compartment below, the full boxes are emptied into the mouth of a spout, which conveys them down into the so-called girls' wax-match room on the ground floor. We follow them downstairs, and enter the same room with them. We find, in this room, which is about ninety feet long by twenty-five wide, six rows of girls at work. They are all working at benches, with troughs before them in the one half, and tables in the other half of the room; every row is formed by about twenty girls, which gives about 120 girls for the room. The girls, with troughs before them, filled with the vesta tapers, are engaged in *framing* the latter for dipping. This is done by ranging the tapers on narrow slips of board with fifty notches in each of them, placed at regular distances of about a quarter of an inch, which is effected by the girls with marvellous dexterity and rapidity. Each board, as it is filled, is pushed into the frame. Sixty boards, of 50 vestas each, complete the frame, which, accordingly, numbers 3000 altogether. As soon as the frame is filled, the girl takes it to the lower end of the compartment, to hand it to the foreman, who enters it against her name on a slate, all the hands in Messrs. Letchford and Co.'s employ being piece workers. There are several little boys engaged at this end of the wax-match compartment, whose occupation it is, from morning to night, to carry each of them two of these frames to the so-called dipping arcade, and bring back from the drying-rooms two frames of the previous day's dipping. But, as the process of dipping is the same for wood matches as for wax matches, it will be the better way to first bring the former up to this stage of manufacture.

The wood matches are made at Messrs. Letchford's of the best Quebec pine timber. The splints were formerly cut on the premises; but it has since been found more advantageous to procure them direct from the saw mills, by which means

the greatest latitude of selection from the very best pieces of timber is afforded. The saw mills supply them in circular bundles of 2000 to 2500 splints, of sufficient length each to be divided into two separate matches. These bundles are first taken to the paraffin dipping department in the rear of the building.

This department consists of a storing room for splints, in which the bundles are first scorched at both ends on hot iron plates, then pitched through a window communicating with another compartment, in which ten or twelve pans are kept filled with paraffin melted by steam. The heated ends of the splints greedily absorb the melted paraffin, so that the process of saturating them takes only a few seconds.

The dipped bundles are now taken to the great wood and box department over the way, which is 170 feet long, and three stories high. Here they are put in a circular frame of corresponding size, and divided into exact halves, by a circular saw worked by steam-power.

Before following the paraffin dipped wood match to the framing department, we may as well at once dismiss, in a few words, the box-making operations, &c., carried on in this part of the premises. The wood used for making the match-boxes is the best spruce. The boards are shaved into thin slices, by a travelling plane, running on a small rail-road, and worked by steam-power. The slices are then cut by other machines into the requisite lengths and breadths for the various parts of the box for which they are intended. The part which is to form the principal body of the box is stamped in a wooden frame, with iron knives or stampers, which serve to break the grain of the wood for bending. Every bit of wood has the letter L stamped upon it. There are several other operations carried on in this part of the building, such as the making of spiral pipe-lights, for instance, cutting reams of paper into strips by a guillotine-machine, ready for the box-makers, &c. The boxes, however, are not completed on the premises, but the materials, fully prepared, are given out to women to finish the boxes at home. This part of the business alone occupies about 200 hands, exclusive of those engaged in the building.

The steam-engine, of some ten or twelve horse-power, which works the whole of the machinery, supplies also the steam for the melting and other operations carried on in the principal building, so that fires are now altogether dispensed

with in the latter, except as regards a few stoves for warming purposes in the framing rooms, as the hot water pipes, by which the entire factory is warmed, have been found insufficient to heat these immense rooms to the proper degree for the work carried on in them, which requires very-supple fingers.

The paraffin dipped splints are taken to the wood-match-framing department, which consists of two immense rooms, each 70 feet long by 35 wide, and very high, with slanting roof, plenty of light, and the most perfect ventilation; which latter, indeed, is most thoroughly provided for in every part of the premises. In one of these rooms, which adjoin each other, there are about 180 girls, in the other about 180 boys, at work, in two divisions each; one being engaged, as in the wax vesta room, in "framing" the wood matches, in the manner already described; the other, in boxing the perfected article. Of this latter anon, as we must, in the first place, follow the wax vesta and wood matches to the "dipping arcade" at the upper end of the framing room. This arcade is about 70 feet long by 15 feet wide, and 30 feet high, with open doors at both ends, securing thus a thorough draught, which reduces to the lowest minimum the danger of inhalation of phosphorus fumes. The fact is we remained for some thirty minutes in this arcade, with the process of dipping the matches in the phosphorus composition going on briskly all the time on some ten slabs, and we really should have been rather at a loss to guess the occupation of the workmen engaged from any hints conveyed through the organ of smell. The lighting composition of chlorate of potash and phosphorus, which was formerly used, has been entirely abandoned by Messrs. Letchford, who use, instead, a phosphorus composition of their own, which it would not be proper in us to divulge. This composition is spread on slabs, kept at a certain temperature by hot water beneath. It is levelled on the slab by means of a roller, and gauged to a certain depth, about one eighth of an inch. In some factories, the clumsy old practice of dipping the matches in the bundle is still pursued, which makes the splints stick together, and produces uncertain lighting "heads," besides increasing the danger of accidents. The dipped frames are now placed in the so-called drying-rooms, a number of brick-built, fire-proof, arched double vaults, with double iron doors between, running from the dipping arcade, and lined

on both sides with racks, on which the frames, with the vestas, matches, vesuvians, &c., are placed, the dipped end hanging downward, to give the dippings the spherical form which liquid bodies have a natural tendency to assume. Many and most efficacious precautions are taken here to guard against the danger of fire. The floor of the drying-room is covered with a layer of sawdust several inches thick, which prevents the ignition of matches accidentally dropped from the frames and trodden upon, and affords, besides, an excellent agent, ready at hand, for extinguishing partial kindlings of frames, by dropping the ignited portion into it. In the event of a wholesale kindling of all the frames in the room, the following very simple, but most efficient, method of stifling the threatening danger in the bud is resorted to:—There are, as already stated, double iron doors between the two compartments of each double vault, and the same between the vaults and the dipping arcade. The air and light are admitted through a square hole in the arched roof; over each of these holes is kept suspended an iron trap fitting air-tight into the opening. By means of bell-handles, outside the vaults, in the dipping arcade, the traps may be let down at a moment's notice. Well, whenever a fire of an alarming character breaks out in any of the drying-rooms, all that the workmen have to do is to shut the doors and let down the traps, when a brief space of time will suffice to put an end to the conflagration, for want of air. On account of the exorbitant premium demanded by the fire insurance offices, Messrs. Letchford prefer being their own insurers; and every reasonable precaution has accordingly been adopted to guard against fire, or to confine any outbreak of it within the narrowest possible limits. All the ceilings, throughout the premises, are lined with iron plate, for instance, and the communication between all the important parts and rooms of the works is by double iron doors. An ample supply of water is also secured, by the main running all round the building, with plugs almost everywhere, and hose attached to them. The main carries to a tank on the roof at the other end of the building, which holds 2000 gallons of water, and there are also numerous stand pipes. As we are still about the dipping and drying rooms, we may as well dispose, in a few words, of the flaming fusees and the vesuvians, which are manufactured much in the same way as the matches. The splint for the vesuvians

is cylindrical, however, and dipped at both ends, first in a composition of charcoal, nitre, &c., then in a phosphorus or lighting composition, slightly differing from that used for vestas and matches. The flaming fuzees are dipped only at one end.

All the compositions used by the firm are made in another compartment, adjoining the dipping arcade. The compositions are melted here, by steam, in a number of pans let into galvanized iron troughs running alongside the walls. Glue is the general binding vehicle used for all the compositions. The lighting or phosphorus composition is prepared in a separate compartment, by two men, thoroughly acquainted with this branch of the business, and with every reasonable sanitary precaution.

The vestas, matches, fusees, and vesuvians, are now finally taken from the drying room, one day after dipping, to the proper framing and boxing rooms, where they are deposited in slate compartments ready for the boxing girls and boys, who remove the matches most dextrously and expeditiously from the frames to the boxes. As every row numbers fifty vestas or matches, the trouble of counting the number in a box is altogether saved. The vestas are put in japanned tin boxes or fancy paper boxes, round and square; the boxes contain 100, 250, &c. The girls have a bit of wet flannel lying on the bench before them, which is quite sufficient to extinguish the matches or vestas that may kindle in their rapid removal from the frames. The vesta boxes are put in parcels of half-a-dozen and one dozen, and taken to the export packer's room, where they are packed in tin-lined cases, for export. A portion of them is taken to the warehouse for home consumption. The wood matches are also done up in parcels and taken to the warehouse to pack for the home trade, thus completing at the front the work commenced at the rear of the premises.

By the excellent arrangements made by Messrs. Letchford, the occupation of the workpeople and children of both sexes employed by them, so far from being unwholesome, is actually rendered salubrious. As to the children, all they have to do requires only a little manual dexterity, easily gained by practice. These children and lads and lasses earn —the smallest and least skilful, about 2s. 6d., the best hands about 12s. a week. We were shown four sisters, from 11 to 16 years old, who thus can earn among them some 25s. a

week—rather a nice help to a poor family. Even the amusements of these children are considerately cared for, a playground being expressly set apart for them. The number of hands employed on the premises ranges between 500 and 600, besides 200 working at home.

To give some notion of the enormous quantity of vestas and matches made on the premises, we may state that the wax taper used for the vestas measures some 600 miles per week, or sufficient, in the course of the year, to go round the circumference of the globe, and leave more than ample length to stretch from England to America, and back again. About 24,000,000 vestas are made per week, besides some 60,000,000 paraffin matches! We cannot leave the establishment without expressing our most cordial approbation of the excellent manner in which the business is conducted in all its branches. A factory of this kind, placed in the midst of a poor district, is truly a very great benefit conferred upon the neighbourhood.

THE BATHGATE PARAFFIN OIL WORKS.

About fifteen or sixteen years since, a thick, dirty-looking oily fluid was observed flowing from the cracks in the sandstone roof of a coal-mine at Alfreton, Derbyshire. The attention of Mr. James Young, who had long been engaged in chemical manufactures, was directed to the circumstance by Dr. Lyon Playfair, and he made a number of experiments with a view of utilising this liquid. These experiments resulted in the establishment of a factory for the production of lubricating and burning oils. After a short period, however, the supply failed, and the manufacture necessarily came to an end. This untoward termination led Mr. Young to reflect on the causes which had produced this natural petroleum, and to endeavour to ascertain whether it could not be obtained artificially. From its situation in the sandstone above the coal, Mr. Young was led to the conclusion that its production was dependent on the natural distillation of the coal by subterranean heat; and, on investigation he found that by distilling coal at a low temperature, he obtained an oily liquid in large quantity.

For the protection of this discovery he took out a patent, and immediately proceeded to establish works at Bathgate, Linlithgowshire—this locality having been selected on account of the existence of the Boghead coal-mines in the immediate neighbourhood. From this small beginning there has rapidly been developed one of the largest chemical factories in the kingdom, with works covering twenty-five acres of ground, and furnishing lucrative employment to upwards of 600 men.

The establishment of this factory furnishes a convincing reply to those pseudo-philanthropists who bewail the decline of simple pursuits requiring unskilled labour, and think that the development of the manufacturing over the agricultural system is the bane of the country. When the Paraffin Works were first established at Bathgate, the village was chiefly occupied by hand-loom weavers, whose average earnings amounted to about 6s. per week. These weavers have now become the intelligent workmen of the factory, their earnings having been trebled by the change; and even the unskilled labourers receive more than double the previous average earnings of the district.

The Paraffin Works are situated about a mile from the Bathgate Station on one of the railways which connect Edinburgh and Glasgow. From the numerous chimneys and the smoke arising from the many furnaces required for the distillation of the oil, the whole place forcibly reminds the spectator of the "Black Country" around Birmingham, an illusion that the smoke-begrimed appearance of the workers materially tends to strengthen. In a volume devoted to practical and applied science, the æsthetics of the subject are, however, out of place, and therefore I will proceed to describe the general details of the manufacture.

The Boghead coal, as it is brought to the works, is a dull, hard cannel coal, in masses of considerable size. It is requisite, in the first instance, that these should be broken into small fragments capable of being conveniently introduced into the retorts, and of being readily and uniformly acted upon by heat. To accomplish this, the blocks are thrown between two revolving toothed cylinders, constructed on the same principle as those of a bone-mill. As these turn round, the teeth crush the hard masses of coal with a horrid scrunching noise which makes one shudder to think of the inevitable fate of workmen falling between

them. This, however, is a contingency that cannot happen, for the opening into which the coal is thrown is purposely made so small, that such an accident is impossible.

On passing down to a lower level, the crushed coal is seen falling out from between the rollers, and a small stream of water may be observed playing over it, to prevent, as far as practicable, the inhalation of the dust by the workmen.

The crushed coal is then laden into large barrows, which are immediately run upon a hoist, that raises them to a level with the tops of the retorts. Arrived at this point, a self-acting break prevents their return.

The retorts for distilling the coal are perpendicular tubes eleven feet in height, four of them constituting a set. These are built into one furnace, and charged by a single workman. The upper ends of the retorts, which project considerably above the platform formed by the tops of the furnaces, are each closed by a conical hopper resembling a common funnel without its narrow tube; the opening of the hopper into the retort is closed by a spherical valve, which is suspended in the retort and pulled up against the opening by a chain worked by a counterpoise. This simple contrivance is rendered sufficiently air-tight by a handful of sand being thrown into the hopper. When it is wished to re-charge the retort, the workman fills the hopper with the broken coal, and then depressing the iron chain, lowers the spherical valve, when the contents of the hopper fall into the retort, the opening being immediately closed again and luted by a fresh handful of sand. From the construction of the retort, the coal is gradually heated as it descends to that part of the tube which passes through the furnace.

On passing down from the elevated platform formed by the range of furnaces, we arrive at the bottom of the upright retorts. These pass completely through the furnaces, and are closed below by dipping into shallow pools of water, that form air-tight joints. The advantage of this arrangement is evident: the spent coal from which the oil has been driven off as it passes through the hot part of the retort gradually descends into the water, and is, from time to time raked away below, the coal from above descending as it is removed. Thus the action of these retorts is continuous, and the distillation goes on uninterruptedly both night and day. The waste refuse or spent coal from the retorts consists of about one half carbon, the remainder being mineral

matter. As this refuse is not well adapted for fuel nor utilised in any way, it accumulates in enormous mounds that cover several acres near the works. One of these accidentally caught fire some time since, and continued smouldering for more than twelve months before it burnt itself out.

The vapours which are produced in the retorts are all conducted by iron tubes to the main condensers. These, like the ordinary condensers in coal-gas works, consist of a series of iron syphon pipes freely exposed to the air. In passing through these pipes, the vapours condense into liquid, a very inconsiderable portion escaping into a gas-holder as incondensible gas. It is this result, so different from that obtained in the ordinary gas-works, that marks the great value of Mr. Young's process. In the gas-works, a high temperature resolves the coal into incondensible gas and coal-tar, the latter being a liquid heavier than water. In the Paraffin Works, a comparatively low temperature, gradually applied, furnishes an inflammable oil lighter than water, with so small a portion of incondensible gas that practically it is of little consideration.

The crude oil produced in the numerous stacks of furnaces by the distillation of the Boghead coal is conveyed by means of iron pipes to a general reservoir; this is a brick tank sunk in the ground, and capable of containing 40,000 gallons. The crude oil is a mixture of various substances, some of which are very volatile, and give off inflammable vapours even at the ordinary temperature of the atmosphere. In order to guard against fire, this tank is covered by a low sheet-iron roof, in the gable ends of which are two iron doors: these are not hinged, but drop like an ancient portcullis, being held open by long iron bars, so that should the liquid in the tank become ignited by any accident, the workmen, by pulling away the iron supporting rods, could drop the doors, and so enclose the ignited oil in an air-tight chamber; and, as if to make assurance doubly sure, a pipe from one of the largest steam-boilers in the works is carried through the roof, and a jet of steam can thus, at a minute's notice, be caused to play on the surface of the oil and assist in extinguishing the combustion.

In this, the more open, part of the works are situated the tanks for the storing of the refined oil. These are circular iron vessels, covered with conical roofs; in size they greatly

surpass the neighbouring cottages, and present somewhat the appearance of ordinary gasometers, without the surrounding framework. These tanks were constructed in the first instance of cast-iron plates connected by screws passing through the broad flanges surrounding each plate. So great, however, is the penetrative or diffusive power of the paraffin oil, that it was found impossible to render the joints tight by screws, consequently riveted wrought-iron tanks are now employed as reservoirs. Each of these tanks is capable of holding about 100,000 gallons of oil. At the time of my visit the aggregate quantity of oil in stock amounted to about 1,000,000 gallons,—a quantity sufficient to dispel the darkness in many hundreds of thousands of homes during the ensuing winter.

The crude oil as first obtained from the coal is a dark-coloured thick liquid, containing all the products of the destructive distillation of the coal. The first process of purification it undergoes is simple distillation. This is performed in cylindrical iron stills of enormous size, weighing about five tons each; in these it is distilled to dryness, the superabundant carbon that it contains being left in the form of a shining black coke. As it is necessary to clear out this coke after each distillation, the retorts are made to open at the ends, so as to admit of its removal. The coke, which is as nearly as possible pure carbon, is employed as fuel in some of the numerous furnaces of the works. From the necessity of heating these stills to redness in order to drive off the whole of the oil, they are subject to a great amount of wear and tear; consequently, the cost of their replacement and repair constitutes an important item in the working expenses of the factory.

The vapour arising from these stills is cooled by being conducted along iron pipes passing through large open tanks sunk in the ground. These tanks have a very small stream of water flowing through them, which answers the purpose of keeping the pipes cool, the specific heat of the paraffin oil vapour being very small, and consequently requiring but a moderate amount of cold water to condense it into the liquid state.

When this first purification by simple distillation has been effected, the oil is further purified by being acted on by strong oil of vitriol or sulphuric acid. As this, from its corrosive action, is a dangerous and, therefore, expensive

material to convey, it is found more economical to produce it on the spot. Consequently, the Bathgate Works include a complete apparatus for its manufacture: there are furnaces in which large quantities of sulphur are burned; vast leaden chambers, in which the fumes, mixed with those arising from nitre, are condensed into the liquid acid; and huge glass evaporating pans bedded in sand, in which the produce is concentrated by heat until it attains the required strength, which is indicated by the specific gravity of 1·848.

In order to ensure an adequate mixture of the paraffin oil and the sulphuric acid required to purify it, both are allowed to flow in the requisite proportions into circular tanks. Each of these contains a revolving stirrer, which throws the whole into great commotion, and causes the intimate mixture of the two liquids, spite of their different specific gravities, the acid being double the weight of the oil. This admixture is continued for about four hours, when the combined fluids assume a beautiful opaque green appearance. On being allowed to rest, the impurities, which are charred and separated by the action of the oil of vitriol, subside to the bottom in the form of a dense, black, heavy acid tar. As this is not turned to any practical use, it is requisite to get rid of it in some way, as it cannot be allowed to pollute the neighbouring streams, and its accumulation would be very inconvenient; it is necessary, therefore, to boil it to dryness, when the solid residue is used as fuel.

In order to separate the remaining impurities, and that portion of the sulphuric acid which is left in the paraffin oil, it is next subjected to the action of a strong solution of caustic soda. This chemical reagent is also prepared at the works, a regular soda factory being in constant operation. This soda is rendered caustic by quicklime; and after having been used to purify the oil, is again worked up and re-used over and over again.

As thus purified, the oil contains four distinct commercial products, that require to be separated from each other in order that each should be made available for useful and economical purposes. To effect this separation, the oil is again distilled. The first elevation of temperature volatilizes the lighter and more volatile portions; these are collected separately, and when purified by a subsequent distillation, yield on condensation the fluid known as naphtha. This naphtha,

however, differs essentially from that obtained from coal-tar; the paraffin naphtha having a specific gravity of ·750, whereas that procured from coal-tar has a specific gravity of ·850. The paraffin naphtha is of great value as a substitute for spirits of turpentine, and as a solvent for India rubber. It is also largely used in those naphtha lamps in which the fluid descends down a long pipe from an elevated reservoir, and being converted into vapour by passing through the heated burner, jets out into a star-like flame. These lamps, from not requiring a glass, nor being extinguished by a powerful current of air, are much employed by costermongers, and workmen in railway tunnels and similar localities.

From its great volatility, the naphtha does not require for its evaporation the heat of an open fire; it is therefore finally distilled in a separate house devoted to the purpose, the heat being furnished by the steam from a boiler situated outside the building. On the perfect separation of the lighter and more volatile naphtha depends the safety of the burning oil. The freedom from danger which has always characterised Young's paraffin oil, shows the care with which this precaution has always been observed at the Bathgate Works.

The burning or paraffin oil, which is the next product in point of volatility, comes over at a considerably higher temperature than the naphtha. As this oil may be regarded as the most important product of the factory, its properties demand more than a mere casual notice. It is a clear transparent fluid, of a very pale yellow tint, with a slight odour. Its specific gravity is ·825, so that a gallon weighs about 8¼lbs. It cannot be set on fire at common temperatures, requiring to be raised to 140° Fahr. before it is capable of being inflamed. Professor Penny has made an elaborate series of experiments to determine the relative economic value of Young's Paraffin oil and the American native petroleums. He found that in small lamps of the usual construction, the American oil burned at an average rate of 267 grains per hour, and gave a light equal to 5·36 sperm candles of standard quality; an imperial gallon of this oil, therefore, would burn 211½ hours, and would produce light equal to 19·44lbs. of sperm candles. Young's oil burned at the rate of 254 grains per hour, and gave a light equal to 6·16 standard candles, at which rate a gallon would burn

for 226·8 hours, and afford light equal to 23·95lbs. of sperm.

The following statement shows the foregoing results in a general form:

	Young's Oil.	American Oil.
One gallon weighs . . .	8¼ lbs.	8 lbs. 1 oz.
One gallon burns . . .	226·8 hours	211½ hours.
Illuminating power of flame .	6·16 candles	5·36 candles.
One gallon is equal to sperm .	23·95 lbs.	10·44 lbs.
Comparative economic value .	123	100
Comparative illuminating power	133	100
Degree of inflammability . .	147° Fahr.	90° to 110° & 128°.

These results afford conclusive evidence of the superior quality of Young's Paraffin Oil as a light-giving material. Its economic value is 23 per cent. higher than the finest American oil, or in other words, a gallon of it is equal to very nearly one gallon and a quarter of American oil.

It is therefore manifest that, from its slow rate of combustion and high luminosity of its flame, as well as from its degree of inflammability, Young's Patent Paraffin Oil deservedly ranks as the best illuminating material of this description at present sold; and its superiority in these respects is owing in great measure to its richness in carbon, and its freedom from the more highly volatile and inflammable liquids.

The third product in point of volatility is the heavy oil used for lubricating purposes. This oil has been extensively used in the Lancashire factories in lubricating the fine machinery, and is preferred to sperm, on account of its superior lubricating qualities, safety against spontaneous combustion, and smaller cost.

As originally obtained, the lubricating oil contains dissolved in it a very considerable proportion of solid paraffin. In order to cause the crystallization of this paraffin from the heavy oils, a low temperature is requisite. As this occurs naturally only in winter, during the greater part of the year an artificial refrigerating apparatus became indispensable. Formerly a machine acting by means of ether was employed; but that has been entirely superseded by a most beautiful refrigerating instrument invented by Mr. Kirk, the resident engineer of the works. By this contrivance the necessity of employing expensive volatile liquids is entirely obviated, their place being supplied by atmospheric air. It is difficult to say which is most to be-

admired—the theoretical perfection or the practical efficacy of this instrument. The detail of its construction would occupy too great a space in the present article; but the principle on which it acts is so simple, that it is readily explained. By the action of a piston working in an ordinary cylinder, a quantity of air is suddenly and forcibly compressed in a separate vessel. By this compression, the latent heat of the air is forced out, and its temperature instantaneously becomes very highly raised. The heat of the air, however, is rapidly abstracted by contact with the sides of the cavity, which are kept cold by a stream of water. The compressed air so cooled is then passed to the other extremity of the containing vessel, and permitted to expand. In doing this, it takes in an equal amount of heat to that which it had lost by condensation; and it abstracts this amount from the surrounding objects, cooling with great rapidity a stream of brine which flows through channels in the vessel. This stream of brine, which is much colder than freezing water, is employed to lower the temperature of the heavy oils down to that point at which the paraffin crystallizes out.

Some idea of the efficiency of Kirk's engine may be gained from a consideration of the fact that a small model worked by hand will freeze mercury, and that the working machine at Bathgate produces a cooling effect equivalent to two tons of ice every twenty-four hours, at a very small expenditure of fuel. The heavy oils containing the frozen paraffin are next put into bags, when the oil drains away, leaving the solid paraffin. It is difficult to imagine any more beautiful substance than paraffin: in its liquid state, it runs like water, looking brighter and more transparent than the neighbouring trout-streams; as poured into the vessels in which it is to solidify, it produces the sound of falling water; and it possesses a high refractive power, that adds greatly to the beauty of its appearance. In a solid form, it is the most elegant of all the substances used for making candles; whilst in its illuminating power it surpasses even spermaceti itself—eighteen pounds and a half of paraffin candles giving the same amount of light as twenty-three pounds of sperm, twenty-six of wax, twenty-nine of composite, and thirty-six of ordinary tallow. Hence, though dearer in first cost, when the actual illuminating power, long duration of burning, and whiteness of light are

taken into consideration, it will be seen that paraffin candles are cheaper than composite. One use of the paraffin candle-ends will commend them to the ladies of the household: a small piece of paraffin added to starch will be found to give a gloss and brilliancy of surface to the starched linen that can be attained by no other addition.

Having now passed in review the various stages of this important manufacture, little now remains to be said respecting the mode in which the paraffin oil is distributed. Accidental violence in transit is better resisted by wooden casks than by metallic vessels, and therefore the former are obviously the best means of ensuring its safe conveyance; but the diffusive power of the oil is so great, that it readily penetrates through the joinings of the staves. This inconvenience has been met in a very ingenious manner: each cask receives a coating of glue internally; this renders it quite impervious to the oil, so that the casks when in the possession of the retailer may be stored without the loss and annoyance of leakage.

The cooperage attached to the works is a large and extensive organization: not only are the casks made and glued, but there is a distinct department where those returned to the works are cleaned and re-glued; and there is even a machine for the purpose of scrubbing the exterior of each, so that on its re-issue it goes forth in a clean form that is not objectionable in any warehouse in which it may be located.

I cannot conclude this hasty and imperfect sketch of this important branch of our chemical manufactures without expressing my thanks to Mr. Young and his partner Mr. Meldrum for the very courteous manner in which the works were thrown open to my inspection: every process was explained, samples of every stage of the manufacture were placed at my disposal for subsequent examination, and the whole manufacture displayed with a freedom which seemed to say—We have here nothing to conceal: we have no objection to our processes being known, and we wish productions to stand upon their own merits.

VISIT TO A PROVISION, CIGAR, AND WHOLESALE GROCERY ESTABLISHMENT.

The stranger who has seen the enormous "stores" of New York, and the gigantic warehouses of London and Liverpool, but who has never visited our provincial inland cities and towns, may smile at the notion that some of even the second and third rate among these might successfully compete with those leviathans of commerce in the size, grandeur, and importance of their mercantile establishments. Yet strange though such an assertion may appear, it is none the less true, as we for our own part had ample and convincing proof afforded us on the occasion of a recent visit to the midland and northern counties of England.

As we think that a description of one of these vast provincial emporiums of the grocery trade may prove interesting to the reader, we have selected for the subject of the present article one from among them which, we believe, may fairly stand as the highest type of the class, being inferior in size and importance to few commercial establishments, whilst greatly surpassing most of them as a work of architecture, and for the completeness and convenience of its arrangements and appointments.

The establishment in question to which we will now proceed to introduce the reader is the Cheese and Provision Warehouse, Snuff and Cigar Manufactory, and Wholesale Grocery Store, of Messrs. Evans and Stafford, Campbell Street, Leicester.

The premises cover an area of nearly an acre. The buildings stand entirely in their own grounds. They form a rectangular block facing the Railway Station yard, which they adjoin, and Trinity Street and Campbell Street. The frontages measure on the longer sides 180 feet, on the shorter 110 feet in length. The appearance of the buildings is extremely handsome and striking, the style of architecture commanding, yet simple and chaste withal. The impression produced upon the beholder is that of a first-class palatial residence rather than of a commercial establishment; yet there is not a single part of the vast construction that is not thoroughly suited for the practical business purposes

for which it is intended, thus affording altogether a splendid illustration indeed of how the hard matter-of-fact exigencies of trade may be allied to the æsthetic and the beautiful, without injuring the one or detracting from the other.

The whole of the buildings are new, having been erected between the years 1858 and 1862, in two parts, from plans prepared severally by Mr. Ordish and by Mr. Shenton, both of Leicester, architects, to whom that town—which besides abounding in glorious relics of antiquity, is certainly one of the handsomest and best built in the United Kingdom—is indebted for some of the noblest and chastest of its modern constructions. The first part, forming a quadrangle, with covered court-yard in the centre, was erected in 1858 from plans made by Mr. Ordish, marked by boldness of conception and originality of design. It is built of red brick throughout, with rustic quoins and stone dressings, enriched on the side facing Campbell Street by eight choice medallions, the work of Mr. William Farmer, of Westminster Bridge Road, London, who has executed also all the other statuary embellishments that adorn every part of the structure. The first of these medallions shows a figure representing Geography, with compass and globes; the second Navigation, with ship's wheel; the third Mercury, with wand; the fourth Justice, with swords and scales; the fifth Commerce, with bales of goods; the sixth Ceres, with wheat-ear and sickle; the seventh, Minerva; and the eighth, Flora. The apex of the roof on the side facing the station yard is surmounted by a very elegant, most artistically designed and tastefully executed figure of Commerce, with horns of plenty at her feet, and holding a ship's rudder in one hand, a Mercury's wand in the other.

This part of the building, which is four stories high with the basement, contains most of the storerooms, offices, workrooms, &c. The covered court-yard, which is adorned by a handsome mural fountain for the benefit of the work-people employed on the premises, is admirably adapted and fitted for loading and unloading goods in all weathers. We saw a large weighing machine in course of erection in the yard, intended for weighing heavy quantities of agricultural and other produce, up to five tons weight.

These premises, although very large, were soon found insufficient for the growing requirements of the rapidly increasing business of the firm, and in 1861 Mr. Henry

Shenton, the gentleman already mentioned, was instructed to make those extensive additions which now form the second part of the structure. The difficult task to make these additions harmonise with the original quadrangle erected by Mr. Ordish has been most triumphantly accomplished by Mr. Shenton,—a success which reflects the highest credit on the artistic taste and skill of that gentleman.

The new buildings consist chiefly of stables, coach-houses, harness-rooms, granaries, store-rooms for hay and straw, and a variety of offices, and are designed to afford increased convenience for transacting the various branches of business carried on on the premises.

The approach to this part of the building from Campbell Street leads through a very handsome archway, with ornamental double gates of wrought iron. The archway is surmounted by a splendid group of sculpture, emblematical of the commercial enterprise of this country. The centre figure is Britannia leaning on her shield and holding in her right hand a gilt trident. This central figure is supported on one side by a statue of Commerce, on the other by a statue of Agriculture. Various emblematic accessories are most tastefully introduced, the entire composition being treated in a highly artistic manner, reflecting the greatest credit upon Mr. Farmer, who, as already stated, designed and executed the whole of the statuary embellishments. These double gates have most elegantly designed panels, with gilt embellishments and monogram of the firm worked in the centre. They are surmounted by handsome chevaux-de-frise. On either side of the archway, and connecting the new with the original building, runs a massive and elaborate cast-iron railing, with gilt embellishments and monogram of the firm worked in, to correspond with the gates. The large open court-yard, to which the gates lead, is paved with granite; the several offices, &c., are reached through it. Ample provision is made here for an unlimited supply of water, which in case of fire can be thrown over every part of the building, through a large hose attached to the stand-pipe connected with the main, and worked by an appropriate engine. At the top of this open yard is a covered yard, which is spanned by a triple arrangement of roof, the central portion being formed with semicircular iron ribs and glass, and having on each side a triangular

roof, also partly glazed, the entire roof provided with ample means of ventilation. The height from the floor to the crown of the arch of the roof is about forty feet. A conspicuous feature is the glazed entrance to the covered yard, which looks a species of Crystal Palace on a small scale. The covered yard is amply supplied with water-works and piping, as it is chiefly intended to be used by the stablemen for washing the horses and vehicles under proper shelter from the weather. There is a machine in the open yard for splitting beans, crushing oats, and cutting chaff.

The building fronting Trinity Street is a continuation of the old warehouse. It is terminated by a circular corner, surmounted by a beautiful statue of Industry, with spinning-wheel, distaff, and spindle, which it may be remarked forms a happy allusion to the method by which the staple manufacture of Leicester was partly carried on prior to the invention of steam. This corner of the building is occupied as a dwelling-house by the over-looker of the horse and carriage department. The whole of the floors on this front of the building are built fire-proof on the principle of Fox and Barrett's patent (rolled iron joists and concrete).

The coach-house, harness-room, and stables correspond with the general plan of the premises, and the perfect order and method observed in every department of this most extensive business is found to prevail equally in this branch of the working arrangements. Thus we find in the harness-room a separate place, with the name printed over it, for the harness of each of the travellers employed by the firm, who visit every part of the United Kingdom. The harness-room is fitted by the St. Pancras Iron Work Company, London, with brackets and every other modern appliance.

Several vans and carts are used by the firm to send out goods within thirty miles round Leicester. Beyond that distance the usual modes of conveyance, per rail and canal, are resorted to. The stables, which afford accommodation for fourteen horses, are fitted up by the St. Pancras Iron-work Company with wrought iron standings, enamelled mangers, Minton's China tiles, and every other modern convenience and improvement. There are five loose boxes, a three-stall stable, and a six-stall stable. Looking over the way, to the opposite side of the yard, we observe two loose boxes unoccupied. On inquiry, we find these to be intended

to serve as hospital stalls for sick horses—another proof of the truly admirable completeness of the arrangements in every branch and department of this vast establishment. A large room over the horse stables is appropriated to the practising of a most efficient brass band of fourteen members, all of them gentlemen in the employ of the firm. The conductor of this band is Mr. Henry Nicholson, of Leicester, the celebrated flutist, well known in the metropolis as a performer at the Exeter Hall concerts.

The ventilation and all other sanitary arrangements are most perfect throughout every part of the building, and each floor is most amply provided with lavatories and other conveniences for the use of the work-people.

Having thus glanced at the architectural features of the building, we will now proceed to pass in brief review the several branches of business carried on in this model establishment.

The business of Messrs. Evans and Stafford is divided into three separate and distinct departments, viz., cheese, provisions, the manufacture of cigars, and the wholesale grocery trade. The executive branch of each of these departments is under the superintendence of a special manager, by which arrangement all chances of confusion are effectively guarded against. The administrative branch of the whole business is under the direct management of the partners, assisted by a staff of book-keepers, invoice-clerks, &c., who have a separate office appropriated to them, provided with all modern improvements, and appliances. This office is on the ground floor, which contains also the private office of the heads of the firm, a most comfortably appointed waiting-room for customers, a spacious sale-room, and, like the basement and the upper floor, an apparently interminable suit of store, weighing, and packing rooms, &c., most of them of the largest size. There we find enormous quantities of home and American provisions, seeds, meal, and every conceivable variety of grocery wares, such as teas, coffees, cocoa, sugar, spices, fruit, confectionery, &c., and an endless list of sundries. These goods are partly in casks, bales, &c., as imported, partly weighed and packed ready for the requirements of the retail trade supplied by the firm, or in process of weighing and packing.

The basement story is more especially appropriated to the storing of cheese and other provisions. The enormous

quantities of these articles on stock here, particularly at the time of the two great annual Leicester cheese fairs, seem to tax even the very considerable capacities of these most spacious stores. There are hundreds upon hundreds of large and small Leicester, Stilton, Derby, Cheddar, Cheshire, Wiltshire, American and other cheese. The Leicesters, Stilton, Derby, &c., are the choicest samples selected from the best dairies. It may be mentioned here, *en passant*, that the samples of cheese sent by the firm to the International Exhibition of last year attracted general attention. An export trade is carried on in these several varieties of cheese to Germany, Canada, and even as far as China.

Among the other provisions we may more particularly mention Lard, Hams, Bacon, and Butter. Immense quantities of lard are rendered here, on Messrs. Evans and Stafford's premises, in large coppers, and run into tins holding about 20lbs. each. Provision is made for Leicester bacon and hams to be cured here in considerable quantities. There are several special compartments on one of the upper floors devoted entirely to the drying and smoking of bacon and hams, where hundreds upon hundreds of magnificent hams and sides and flitches of bacon may be seen undergoing the several processes required to fit them for the provision market. The smoking-room is so constructed that all smoke is carried off outside the building. Oak sawdust is used for fuel.

The trade in agricultural seeds also forms an important branch of the business; many of the farmers purchase their seeds and take them back when they deliver their cheese.

Some slight notion of the extent of the commercial operations carried on by the firm of Messrs. Evans and Stafford may be formed from the fact that thousands of tons of weight of goods leave the premises in the course of every year, leaving altogether out of account the very considerable tobacco and cigar business.

The manufacture of cigars is carried on, as already stated, as a quite distinct and separate branch of the business.

The various sorts of tobacco used for the manufacture of cigars are imported from Havana, Columbia, South America, Manilla, Germany, and other countries, in bales, cases, serons, &c.

The tobacco as delivered from the docks is brought to the

leaf-room on the basement floor, where the hands are taken asunder, and the article is prepared for the subsequent stages of manufacture. It is then taken to the stripping-room, where the stalk is removed. The stalks are used to make snuff, which, however, is not ground on the premises, but simply flavoured and made up for the trade. The stripped leaves are then carried by a machine-lift up to the manager's room on the fourth story, where they are given out to the workmen and girls to be made into cigars, which are then returned to the manager's room for examination.

The cigars are made in three immense, most efficiently ventilated rooms, lit at night by star-burners from above, running, one right ahead, and one from each side of the manager's place, bringing thus every part of the work under his immediate inspection and supervision. The younger hands, or learners, make the bunches or insides of the cigars, the more experienced hands are employed in covering them. At every stand there is a gauge set to the required length of the cigars, and the excess is cut off at the broad end with a knife.

Cigars vary much in size, of course. There are, for instance, made here the so-called "Queens," 250 to the pound, the "Napoleons," or "Emperors," 50 to 60 to the pound, &c. &c. The girls employed in the factory make the more common sorts, the men, who are all of them experienced hands, the finer sorts of Havana, and Columbia cigars, which for quality of leaf and workmanship certainly need fear no damaging comparison even with the best Havanas and Columbias of foreign make.

The manufactured cigars are, as already stated, sent back to the manager's room for examination. Those that are passed by him are then taken to the drying-room, where they are arranged on movable slides with perforated zinc bottoms, placed in racks, and exposed to a temperature of between 80° and 90° Fahr., which is imparted to the room by a stove, with a long pipe running across the room in its entire length. The room is adapted for thirty racks, with fourteen slides to each.

After drying, the cigars are taken to the sorting-tables, where they are sorted according to colour. The sorted cigars are then put into large cedar chests to season, which takes from one to twelve months, according to the quality of the article; the Columbias and Havanas requiring, of

course, a much longer time to season than those made of the lighter sorts of German tobacco. When properly seasoned, the cigars are finally boxed or bundled, a machine being used for the latter purpose, to give the bundles an hexagonal shape.

The boxes of cigars vary from ¼lb. to 12lbs. each. Besides the well-known common cigar boxes, an infinite variety of fancy boxes are used, most of them got up in a very superior style. We saw some elegant boxes, in imitation of books, with rich velvet backs, and photographic and other likenesses of the Prince of Wales and the Princess Alexandra and other celebrities on the covers; others adorned with choice medallions; others, again, in form of caskets or cabinets, &c.

As to the quantity of tobacco manufactured into cigars at Messrs. Evans and Stafford's establishment, a glance at the many hundreds of samples hanging in the sample-room suffices to show how very considerable this must be. The samples are hung up here for revenue purposes. Each of them, weighing about 4lbs., represents a quantity of from 1 cwt. to 7 cwt. of the different sorts of tobacco sent in from the docks.

The number of hands employed in the establishment is between 200 and 300.

With grateful acknowledgments for the courtesy shown us in our visit, we now take our leave of what we may truly pronounce one of the most interesting and best appointed and conducted commercial establishments in England.

VISIT TO A TOBACCO MANUFACTORY.

Though London cannot cope with Birmingham in the number, variety, extent, and grandeur of its establishments for converting raw produce into articles for the use or delight of man, yet there are some branches of manufacture in which the palm of excelling superiority must be unhesitatingly awarded to the metropolis. Among these the manufacture of tobacco occupies a conspicuous place.

As the "fragrant weed" is an old-established favorite

with, at least, a large section of the public, we think a brief narration of what we saw on the occasion of a recent visit to one of the leading tobacco factories in London may not prove altogether uninteresting to the reader.

First, however, we have to make a few introductory remarks concerning the raw material. The early history of the tobacco plant is involved in considerable obscurity. The Chinese and other Asiatic nations maintain that the herb and its uses were known to them long before the discovery of America was even dreamt of, and there is no valid reason to doubt the correctness of the assertion. The old notion, so generally received hitherto, that the name of the plant was derived from Tobago, one of the West Indian islands, or from Tobasco, a province of Yucatan, in Mexico, is pretty nearly exploded now. It had its origin in a mere similarity of sound, and could not possibly have arisen had the earliest writers upon the subject been consulted. Father Romana Pano, chaplain to Christopher Columbus, who was left behind on the Island of Hayti, in 1496, tells us that the Indians there delighted in smoking the leaf of the *Cohoba*, or *Gioia*, or *Yoli*, which is simply our tobacco plant, through pipes with a species of double bowl, and that they called the blowing of the smoke through the nose, making *Tabaco;* and Franciscus Hernandez de Toledo, who was sent by Philip II. of Spain, in 1560, to Mexico, to study the natural history of the country, informs us that the natives were addicted to smoking the leaf of the *Yetl*, or *Pycyetl*, which is simply the Mexican name for tobacco, through hollow tubes an inch and a half long, called *Tabacos*. These statements find ample confirmation in the writings of Hernandez de Oviedo, who was Alcalde of St. Domingo in 1535; Geronimo Benzono, of Milan; Father André Thevet, Jean de Lery, and others. There can, therefore, be no doubt about the derivation of the name of the plant from that of the instrument used for enjoying it.

It would appear that the Portuguese were the first to introduce the tobacco plant into Europe; they brought it from Florida, about 1555, and cultivated it in their gardens. The Superintendent of the Royal Records at Lisbon recommended it in 1558, to Jean Nicot, the French Ambassador to Portugal, for its medicinal virtues. Nicot having effected with it several cures of cancer and other dangerous diseases, sent it to Catherine de Medicis, in 1560. The plant was

called after him *Herba Nicotiana*, or *Nicotiana tabacum*, which has since become the generally recognised name. Catherine de Medicis and the Grand Prior of France, as well as Prosper de St. Croix, the Papal Nuncio to the Court of Lisbon, did much to promote the cultivation of the plant in France and Italy; hence the names of *Herba reginæ*, or *Herbe de la reine*, *Herbe de St. Croix*, *Herbe du Grand Prieur*, by which we find the tobacco plant occasionally designated.

The new plant, employed at first for medicinal purposes alone, was speedily turned to use also after the fashion of the American Indians, and so-called *Tabagies*, *i. e.* places of amusement specially devoted to smoking of tobacco and drinking, soon began to abound in France and elsewhere. According to Lobel, there can be no doubt but that the new plant was first introduced into Britain from France, and that it was cultivated in England before the year 1570; also that Sir Walter Raleigh and his companions smoked it in pipes as early as the year 1584. The generally received notion that Sir Francis Drake was the first who imported tobacco into England—having brought it, in 1586, from Virginia—is, therefore, clearly founded in error. The habit of smoking tobacco, first introduced into England by Sir Walter Raleigh, became speedily popular, especially at court and in the higher classes of society; so much so, indeed, that both gentlemen and ladies actually carried their pipes with them to the theatre—nay, even to church! In other parts of Europe also, and in Asia and Africa, the new fashion spread with astonishing rapidity—everywhere people took to smoking, chewing, and snuffing tobacco. It was not long, however, before the Church began to scent the agency of Satan in tobacco-smoke; learned theologians argued and clearly proved, to their own satisfaction, that the use of tobacco had a direct tendency to destroy the efficacy of fasting, and ecclesiastics were accordingly speedily prohibited by several councils from indulging in the pernicious herb, which was, moreover, objected to also by certain Protestant sects, upon the same ground as coffee was, at a later period, in some parts of Germany—viz., simply because it was not mentioned in the Bible! The governments, as usual, followed suit; Denmark and Prussia absolutely prohibited the cultivation and importation of the article. Michael Feodorovitch Tourieff, Czar of Russia, tried to put

it down, regular Tatar fashion, by punishing a first transgression with a bastinado, a second with the loss of the nose, and a third with that of the head of the transgressor. Popes Urban VIII and Innocent XI fulminated two of the most thundering bulls against it, which, however, like many other Papal achievements of the kind, remained mere idle sound and fury, even in Ireland, where the prohibited herb flourished in a most extraordinary degree in spite of Pope and King; for that strange caricature of rulership and wisdom, James I, had, of course, also joined in the hue and cry after the unfortunate plant, and let fly at it a ponderous mass of nonsense, which he termed his "counterblast." But, canny and thrifty Scot that he was, instead of attempting to prohibit its use, he taxed it to a most unconscionable extent, and made much good money out of it. In the region where Mahometanism sat enthroned, the green and the yellow slippers were, for a wonder, for once seen go hand in hand, or rather foot to foot, the two Popes of the respective creeds, Sultan Amurath IV of Turkey, and Schah Abbas II of Persia, acting both with equal rigour and equally horrible and disgusting cruelty against all transgressors of the laws of absolute prohibition decreed by them against the use of tobacco. Finding, however, all prohibitions and penalties unavailing, the several governments, one after another, followed the example set them by Great Britain, and turned the growing indulgence in the new luxury into a profitable source of revenue. Hence the cultivation and manufacture of tobacco remain even to the present day almost everywhere in Europe subjected to fiscal regulations and restrictions, many of them of a most ridiculous and vexatious kind.

There are some thirty different species of the tobacco plant known to botanists, of which the two most important ones are the *Nicotiana tabacum* and the *Nicotiana rustica*. The former of these, a native of tropical America, is at present cultivated also in the Southern States of North America, particularly in Virginia, Ohio, Kentucky, and Maryland; in many parts of Central and Southern Europe; in Africa, and all over Asia, the islands of the Indian Archipelago, Australasia, and Polynesia. The latter, which furnishes the Syrian tobacco, is cultivated chiefly in Syria, Asia Minor, and parts of Persia; also in Germany and France. The tobacco plant belongs to the natural order of

Nightshades (*Solanaceæ*), and to the Pentandria Monogynia of the Linnean system. The leaves, which are the principal part for which the plant is cultivated, are cordate, or lanceolate. The necessarily restricted limits of this article will not allow us to enter into a description of the mode of cultivation, and the gathering and preparing the leaves for the factory, and we must therefore rest satisfied here with a brief allusion to the principal ingredients that constitute the leaf, and impart to it its peculiar properties. The most important of these ingredients are *Nicotin* and *Nicotianin*. The former is an acrid, volatile, colourless liquid, of an alkaline nature, a pricking, burning, very persistent taste, and a pungent, disagreeable odour. The latter is of a fatty nature; it has an aromatic, somewhat bitter taste, and smells like tobacco smoke. Nicotin is a virulent poison.

After these introductory remarks we will now proceed to the snuff and tobacco manufactory of Messrs. Huxley and Co., in the Whitechapel Road, who have kindly invited us to a sight of their establishment, and of the several processes and operations carried on in it.

The premises, which are quite new, having been recently rebuilt, cover a vast area, extending to a depth of 250 feet, right down to Montagu Street. We are most courteously received by Mr. Clarke, one of the partners of the firm, who kindly offers to conduct us over the establishment, and to give us every information as to the nature of the processes and operations which we are about to witness, an offer which we of course gladly and thankfully accept. Mr. Clarke calls our attention, in the first place, to numerous large hogsheads and bales then unloading at the wide entrance-gates of the warehouse, and tells us, *en passant*, that the duty on every one of the hogsheads, which weigh about 15 cwt. each, amounts to £250, and must be paid to Her Majesty's Commissioners of Customs before a single leaf of the contents can be touched by the manufacturer.

Mr. Clarke then conducts us to the first compartment of the leaf-room, to which are taken also the hogsheads and bales which we saw unloading at the door. These contain a great variety of leaf. We have here hogsheads from Kentucky, Virginia, Maryland, Ohio, &c. As it would prove rather a tedious operation to unpack the leaves from them, a more expeditious process is resorted to, consisting simply in sawing the cask asunder longitudinally, and removing

the two halves from the tobacco packed up inside. Besides the hogsheads, we have bales from Columbia, Paraguay, Brazil, and other parts of South America, Cuba, and the other West Indian Islands; also from Java, Holland, Germany, Alsatia, &c., varying in weight from 1 to 5 cwt.

The leaves unpacked from the hogsheads and bales are then taken, first, to another part of the premises, where they are *stalked*, or stripped of their middle ribs by the hands of boys. We saw a small regiment of boys at work, and could not help admiring the clever and expeditious way in which the youngsters do the trick. The leaves turn out occasionally too dry to admit of the easy removal of the middle rib; they are in such cases exposed for a few minutes to the action of steam in a steam closet near at hand, to make them sufficiently supple for the operation.

Of the middle ribs or stalks we shall have occasion to speak anon. The split leaves are now carried back to the leaf-room, where the several sorts are mixed together, in certain definite proportions by weight, to produce the different kinds and qualities of cut tobacco which it is intended to manufacture. This branch of the business requires the most consummate knowledge of the produce of the several countries from which the supplies are drawn, as well as a thorough knowledge and subtle appreciation of the tastes of the different classes of consumers,—a knowledge which no theoretical teaching can ever be expected to impart, but which can be acquired only by many years' practice.

Each set of mixed leaves is, after its removal from the weighing scale, spread out, separately, on the floor of the compartment, where the leaves are then sprinkled with pure water. The object of this operation is simply to moisten the leaves, which generally arrive at the warehouse in a state of great dryness, and to make them sufficiently supple for the subsequent process of pressing. The heaps, which, of course, are carefully kept asunder, are turned over repeatedly to ensure an equable distribution of the moisture. After twenty-four hours, they are pressed or squeezed into square cakes, technically called boxes, two feet square by four inches thick, and weighing about 25 lbs. each. These cakes are then transferred to the cutting machine, or cutter, where they are placed on a smooth bed within a horizontal trough, and pressed down tight by a follower and screws,

to keep them quite compact, so that they may oppose a firm resistance to the knife, ensuring thus a clean cut.

The cakes are progressively advanced upon the bed to meet the cutting blades, the degree of fineness of cut being regulated by the size of the rachets of the wheel.

The edges of the cutting blades are made of the best tempered steel. The cutting machines are worked by steam power; there are three of them constantly at work here, cutting up about 5000 lbs. of tobacco a day. The cut tobacco is taken to another compartment, where we see a kind of long table with four horizontal troughs or pans let into the top. The first and third of these troughs have each a canvas bottom stretched over a perforated copper plate; these are called *steam pans*. The tobacco is first thrown into the second trough, which lies between the two steam pans, and serves as a receptacle, from which the pans are fed; it is then transferred to the pans on both sides, and the steam being turned on from below is made to pass through it for about two minutes. This operation is simply intended to separate the fibres of the cut tobacco, which, from the great pressure brought to bear upon the cake in the squeezer and in the cutting machine, stick close together in a tangled mass. This object accomplished, the loosened tobacco is tranferred to the fourth trough, which is technically termed the *fire pan*; on the smooth sheet-iron bottom of this, which is also heated from below, the steam is dried out again; this operation also occupies about two minutes. The hot tobacco is then carried, in wooden trays, to the *rack*, where it is spread in layers about two inches thick, and left to cool. When it has become quite cold, it is folded up into what the workmen in the factory technically call *cobs*. These cobs present the shape of large round loaves; they weigh about eight pounds each. A cob of each different sort of tobacco prepared in the course of the day is taken to the sample-room, to undergo proper inspection next morning. A portion of the finished article is now taken to the packing-room, where it is packed in casks or boxes, ready for despatch.

The other portion is taken to the first floor, where we are invited to follow it. Here we enter a spacious, well-lighted gallery, with a table running from end to end on both sides. This is the moulding room, constructed expressly by the firm to meet the demand of the dealers in

tobacco, who find it advantageous to receive the article in the quantities in which they usually sell it, viz., 1 oz., 2 oz. and ¼lb. packets. The operation of packing is performed here by a number of young girls between twelve and fourteen years of age, under the superintendence of a forewoman. These girls are divided into parties of three—one to weigh the tobacco, the other two to mould the packets. The packages are round; they are made of paper, by means of wooden moulds and tinplate funnels. The nimble fingers of the children perform this operation with astonishing facility and rapidity; as fast as the one of the set can weigh, the other two complete the packets, and the weighers seem to have acquired such expertness in their branch of the performance that the balance almost invariably stands at the first try. To make the wooden moulds more durable, they are furnished with brass tops; and to prevent the tables splitting by the constant knocking and friction inseparable from the operation carried on on them, the front of them is made of teak. The smaller packages are made up by the forewoman into 1 lb. packets, which are then sealed over small gas-burners, connected with the pipe by flexible india-rubber tubes.

A lift opening into the gallery serves to convey the various articles from the ground floor to the first floor, and *vice versa*.

A few steps at the end of the gallery take us up into a spacious room filled with a very large number of chests of various sizes. Our conductor informs us that this is the cigar warehouse, and that these chests contain every sort and variety of cigars, from the lordly Cabana and the magnificent regalia down to the humble cheroot and the penny Pickwick. To enter here into any detailed description of the manufacture of cigars would be apart from the general intention of our visit, which was more particularly devoted to witnessing some of those processes by which tobacco is prepared for the ordinary retail market.

An equally brief allusion must, for the same reason, suffice here with regard to the snuff department. The stalks, or middle ribs removed from the leaves, undergo a first process of comminution in a cutting-machine, which is worked by steam power on the ground floor of the premises. The cut pieces are then sent away to be ground

in mills, mostly worked by water power; the powder is brought back to the factory in large hogsheads, to undergo the final operations and manipulations to fit the article for sale and consumption. Part of the grinding is, however, done on the premises on the first floor, in a grinding mill worked by steam.

The manufacture of rolled tobacco is carried on in a separate warehouse. The Virginia leaf alone is used for making the different sorts of pigtail, bogie, Alloa, and Cavendish. The leaves intended for the purpose are first sprinkled with water to make them quite soft; they are then stripped of their middle ribs, and those intended for the thinner sorts cut across the middle into two halves. They are now wound or spun into ropes of different sizes, with the aid of a so-called spinning mill with fly-wheel, the operation somewhat resembling the twisting of twine and rope on a rope-walk. A boy acts as feeder, handing the leaves to a man who rolls them on a table, by means of a flat-iron strapped to the hand; this instrument is technically called a *hand-board.* The ropes are wound into barrel-shaped rolls of 1, 2, or 3 lbs. weight. The large sized ropes are also first made into rolls, which are then squeezed quite flat in a press; the flattened cakes constitute the Cavendish of the shops.

The barrel-shaped rolls of pigtail, &c., are subjected for some time to a high pressure, which makes them ultimately turn black, the natural juice of the tobacco getting squeezed through the whole mass.

Lastly, in the rear of the premises we are shown a steam-engine of ten horse power, with boiler-house adjoining. This engine supplies all the steam power required in the several departments of the establishment.

This ended a pleasant and instructive visit to another of Our Business Houses in London.

PAPER BAGS.

It was once remarked by an eminent natural theologian, in illustration of an argument, that few people knew "how oval frames were turned," and it is not too much to say, that a similar charge of ignorance might be brought against mankind in general with respect to a hundred articles with

the daily and almost hourly use of which they are perfectly familiar.

Not to multiply illustrations, how many people could (until they had referred to some of our former pages) give even a tolerable description of the manufacture of a frying-pan, of a pane of glass, of a steel pen, or of a parlour candle. Even the common method of making and preparing pins and lucifer-matches is by no means extensively understood, although these two articles are representative not only of extreme familiarity in use but of insignificance in value. That convenient and universal envelope known as a "paper bag" is in such constant request both by shopkeepers and by such well-regulated families as are in the habit of consigning parcels to their friends, that there has long been a growing necessity for some increased facilities in its manufacture. Not that the public were particularly interested; so long as there was an improvement in the article, and at the same time an ample supply, the matter was duly taken for granted; a paper bag is a thing of such small significance, so is a single hair—the inconvenience of a sudden deprivation either of hair or of paper bags in the aggregate would be terrible, but the supply of both is as we say taken for granted—why should anybody trouble themselves about the method by which they can be most perfectly produced?

To our readers, however, paper bags may be of greater significance than is altogether obvious on the first glance at the subject, when it is considered what an important part they sustain in the history of shopping. In their interest, then, we visit the manufactory of Mr. C. T. Youngman, who has succeeded in applying machinery to the manufacture of every sort of bag known to the London trade.

Having skirted the new terminus of the Underground Railway, and arrived in that labyrinth which leads to Cowcross-street, we suddenly find ourselves in the open, but somewhat ruinous, thoroughfare of Victoria-street, near the Field-lane Ragged Schools, and at the side of this building, in West-street, Smithfield, is Mr. Youngman's factory, where brown, white, blue, and grey paper, would mingle in one huge envelope, involving the entire neighbourhood, were they not all neatly rolled up on wooden cylinders like brown, blue, grey, and white holland, and the rolls standing on end in a warehouse devoted to the purpose:

It may surprise many of our readers to know that some of the pieces of paper, which are of about uniform width, are more than ten miles long, and that they could be made to almost any length but for the inconvenience of carriage. The machines by which these lengths are converted into bags are so marvellously adapted, that the process is as simple as it is rapid. The first step is the removal of one of the gigantic rolls of paper, whether it be brown, grey, purple, glazed blue, cartridge, or whitey-brown, to a room where it is placed in the cutting-machine. Here it is rapidly unrolled and drawn along the bed of the machine, while during its passage circular revolving knives divide its width into strips, according to the size of the bags required.

As the paper is drawn off its original roller by the action of another roller, which draws it on to itself, and as it is cut longitudinally during its passage, the strips come from this machine still rolled tightly, and each of them the length of the original piece. These are now to be made into bags, and for that purpose are at once transferred to a machine, where they are once more rolled off, and drawn upwards over another roller; as they pass this on their way to the flat metal table which forms the bed of the machine, their edges are subject to the continued action of running bands, which first passing through a reservoir of paste above, wet them evenly and completely.

The paper next travels along the metal table until it passes the place where the descending lever knife cuts off a length sufficient to form the bag. This is again carried to a cleft in the metal table, where a falling lever folds it precisely in the centre, and by the same action carries it down the slit. The pasted edges are there brought together and pressed, and the complete bag, the bottom of which is of course the part where it was folded by the descending lever, is discharged on to a low wooden table, where a girl sits in readiness to receive it. The rapidity and precision with which the operation is effected is truly marvellous; but our wonder is increased when we are shown that by another adaptation of the machine it will turn out the stronger description of bags used by grocers where all three edges are pasted. This is effected by a contrivance which carries the two pieces along simultaneously until they meet at the precise moment, when they are subject to a pressure that causes them to adhere firmly, and at the same time

secures them against defective pasting. By an easy adjustment of knives, and of the position of the machines, bags of every shape can be produced with equal facility.

Such of the bags as are ordered to be printed are removed to a steam-printing press, and are finally packed up into bundles, and consigned to their various destinations.

When all the machines are at work, Mr. Youngman's factory will produce some 130,000 bags a day; but he will probably have to increase his plant, since he finds it difficult even now to execute the orders which he has already received.

The bags which are taken from the machine are, of course, not packed at once, but are sent to the drying-room, and laid out upon long tables, until the edges show no sign of moisture. In this drying-room—heated by pipes, through which steam is carried from the engine boilers, and over which we have to step in a way that reminds us of a street where there has been a fire, and the hose occupies the roadway like an exhausted sea-serpent—there are a vast number of pasteboards suspended from the ceiling. These are made in an upper room, where several men stand at a long bench, each of them provided with a sort of short hearth-broom, with which he lays the paste unsparingly upon the pile of blue and white paper before him, adding a fresh layer every time, and seeming, to the ignorant visitor, to be wasting enough batter to supply all Smithfield with a week's muffins. Muffins are suggested by the great cauldrons and pans of paste set out to cool, by the floury appearance of the men, and the white splashes and "blobs" that pervade even the walls and the ceiling. These pasteboards are dried and subjected to a powerful hydraulic press, after which they pass between iron rollers, and are finished by a steam-cutting machine.

To keep all the machinery in order, there is a thoroughly-fitted engineer's workshop, and this, with the stock-rooms, comprises the remaining portion of the factory. The work is done almost entirely by girls and women, and is, for the most part, light enough to be performed by the youngest of them.

Before leaving, we pass a number of these, who were employed before a long trough in sorting shreds and shavings of paper,—the waste of the manufacture. This is of all sorts and colours, and, when separated, will be

sent off to the mills to be remanufactured. This reproduction is in itself suggestive; and by the time we have once more turned into the broad street leading to the city, we find ourselves assigning to paper bags their proper place in the social economy, as being connected with every phase of human life, from the taws and toffee of childhood to the tea and turnip-seed of maturer years; with each successive stage of confectionery, haberdashery, drapery, hosiery, bakery, and, above all, grocery; and with the small change of existence in general.

MUSTARD AND STARCH.

A DAY AT THE CARROW WORKS, NORWICH.

THE annals of our country are written in characters which fade but slowly under the corrosive breath of Time. We can read the wondrous story of England in the earthwork and masonry of successive generations, just as we may trace the growth of a tree by the concentric layers of wood. The mystic stone circles of the Druids, the hard roads and deep camp trenches of the Romans, the frowning castles of the Saxons and Danes, and the noble cathedrals of the Normans, are grand memorials of the nation's origin. Such substantial vestiges of our ancestors, with the more recent examples of ecclesiastical, municipal, and domestic architecture, form a complete chain connecting the bright present with the dim past.

This thought is forced upon us as we thread the winding streets of the good city of Norwich, where but few links are wanting in the chain of antiquities. The place has been an important centre of life and industry for thirteen centuries, and as we survey the motley aggregate of buildings, we seem to see the history of those centuries fossilized. Much should we like to pry into the nooks and corners of this old city, but we have travelled thus far from the sound of Bow bells with a very different object. We are here, not to study the works of dead generations, but to examine into the industry of the living. A great factory, situated in the suburb called Carrow, claims our attention to-day. While

walking thither, however, we may indulge our vein, and allow our thoughts to sail up the stream of history. On reaching the brow of the hill overlooking Carrow, we come upon some picturesque ruins of the embattled wall of flints with which mediæval Norwich was fortified. The wall was completed more than five hundred years ago, and even then the city was noted for its woollen manufactures, a large number of skilful weavers from the Low Countries having settled in the place. Before the foundations of the wall were laid, a Benedictine nunnery was established on the plain below, and some crazy fragments of the buildings are still visible. In the days of this religious house, Carrow was a calm retreat, and the vesper-bell was heard by few besides the prioress and her nine nuns. At the present time, however, the aspect of the place is not suggestive of religious seclusion, for the principal feature in the landscape is a grand mass of brick buildings with three tall chimney shafts, forming the Mustard and Starch Works of the well-known London firm of J. and J. COLMAN. We survey this unmistakeable sign of modern activity and enterprise with intense satisfaction; for on contrasting it with the ruins in the neighbourhood we obtain incontestable evidence of England's progress. While in the retrospective mood we remember that mustard—one of the chief products of the factory below—is a very ancient condiment. It has been eaten with the good roast beef of this country ever since the Roman invasion. The cooks of ancient Rome prepared it for the table with the unfermented juice of the grape; hence it was called *mustum ardens* (hot must), from which term the English word "mustard" and the French "moutarde" are derived. It must not be supposed, however, that the invaders of Britian were the first eaters of mustard, for they originally obtained the condiment from Egypt, where it had been in common use from the most remote time. The history of the mustard-pot, therefore, commences ages before the history of Norwich, even though we connect this city with the Roman station of Venta Icenorum, or Caistor, from which it may be said to have arisen. An old distich records that,

"Caistor was a city when Norwich was none.
And Norwich was built with Caistor stone."

We must loiter no longer outside the factory, for we understand that it is a good day's work to inspect the various

departments. On entering the gates we cannot help being impressed with the magnitude of the establishment, and are reminded of those great hives of the North, the cotton factories. There are four large blocks of buildings divided by broad streets, and many minor structures which serve as offices and workshops. The river Wensum washes the lower portions of two of the main blocks, and as this stream is navigable for vessels of 120 tons, the advantages of the situation which the Messrs. Colman have chosen are obvious. A railway has been laid down in the principal street or avenue, and we are informed that this connects the factory with the Eastern Counties line.

The resident partner receives us with the unstrained courtesy which is so characteristic of an English gentleman. He knows our mission, and is prepared to devote the entire day to the elucidation of the processes carried on in the works. With a guide so competent, we have no reason to fear mystification, however numerous or complicated the operations may be. We commence our round of inspection with the warehouses in which the raw materials of the mustard manufacture are stored. Here we find just such an assemblage of sacks as may be seen in any great corn warehouse; but on peeping into these sacks we discover either the brown or white mustard seeds. The brown seeds are very minute, each being but little bigger than the head of an ordinary-sized pin. They are the produce of the black mustard, the *Sinapis nigra* of botanists, which is extensively cultivated in the vicinity of Wisbeach. The white seeds, which are familiar to all growers of small salad, come from the species *Sinapis alba*, which is principally raised in Essex and Cambridge. The average price per bushel of the brown seeds is about 15*s*., and of the white seeds 12*s*. Mr. Colman informs us that he has occasionally given as much as 34*s*. a bushel for the former, and 23*s*. for the latter. The seeds only appear in the markets of Wisbeach and Mark-lane once a year, and the few manufacturers who use them are consequently compelled to keep large stocks. To preserve them for a long period is a task which the farmers have hitherto failed to accomplish, but in these warehouses the temperature and ventilation are so carefully regulated that the seeds will remain unchanged for years.

The preliminary operations of cleansing and drying the seed are performed by means of the ordinary dressing

machine and kiln. That so much dirt should be rubbed and blown off those little seeds, which look so clean, is something really surprising, but beyond this there is nothing remarkable in the dressing process. The kiln is precisely similar to one used for drying corn, being a heated chamber floored with wire-gauze; on looking into it, however, we are charmed with the novel appearance presented by the thick layer of tiny seeds which covers the entire floor.

We now enter the main building of the mustard works, and Mr. Colman directs our attention, in the first place, to the sieves which are employed to separate the flour of the seed from the husk. These sieves are all formed of silk tissue, and are very costly instruments; some are of extraordinary fineness, indeed one which is shown us calls up the absurd image of a tambourine made with a slice of London fog instead of parchment. The room in which these sieves are used is now exposed to view, and for a few moments we are utterly bewildered with the rapid movements of the workmen and the machines. The men so uniformly coloured with the yellow dust remind us of the demons of a pantomime, but what they are doing baffles our comprehension. By attending to one thing at a time, we shall, perhaps, be able to detect order in this scene of apparent confusion. On one side of the room is a series of vertical rods of wood, each of which has a bulb of iron at its lower extremity. These rods are continually jumping up and down like the beams of an old fashioned stamping-mill. They jump to some purpose, too, for beneath them is a corresponding series of strong iron vessels or mortars, which are all partially filled with bruised mustard-seed. Though these iron-shod rods puzzled us a little at first by their peculiar action, they are obviously merely steam-worked pestles. Before being subjected to the ill-usage of these unfeeling bruisers, the seeds are crushed between iron rollers to separate the fixed oil. The workmen who superintend the pounding machines are continually adding the crushed seed or removing the finished powder, and it is only by watching them narrowly that we find out how they contrive to escape the hard blows of the pestles. When a man has to put his hand into a mortar, he gives the ascending pestle an upward jerk, which slightly increases the length of its stroke, and brings it under the influence of a simple catch. When he has adjusted the contents of the vessel to

his satisfaction he releases the catch, and down comes the pestle as before. The pounded material, consisting of both the flour and the bran of the mustard-seed, may be seen on every side, in great heaps of a golden-yellow colour. To part the chaffy scales from the impalpable powder is the object of the process which now claims our attention.

This process is a very common one, being simply that of sifting; but, as with the pounding, steam-power here supplies the place of muscular force. The sieves are arranged loosely in frames, to which a rapid eccentric motion is given by means of revolving shafts. Each frame will hold eight sieves, and may be looked after by one man. We cannot help contrasting the characteristic movements of the two kinds of machines at work in this room. The pestles on one side seem to be continually practising the monotonous jumping dance of "The Cure," and the sifting frames opposite to be suffering from some horrible nervous affection. The mustard flour is shaken through many sieves of different degrees of fineness, and when it leaves this room the remains of the seed-coat are only visible to the microscopic eye.

The brown seeds and the white are never operated upon at the same time, as it is important that the two sorts of mustard should be mixed in definite proportions. The flour of the brown seed is far more pungent than that of the white, and is the essential constituent of the condiment. A mixture of the two sorts is, however, generally considered more palatable than the simple brown mustard flour. The mixing of the different kinds is a mere repetition of the sifting process.

The public generally suppose that it is impossible to obtain genuine mustard. Such, however, is not the case; for although it is not denied that some of the qualities, to suit the tastes of consumers, are prepared with a certain admixture of the finest wheaten flour and a very minute proportion of turmeric, Messrs. Colman's mustard can be procured perfectly genuine. Most of it is sent from the factory in sealed tins, packets, and bottles, every one of them bearing the autograph of the firm and that trade-mark—so suggestive of roast beef—the Bull's Head. The absolutely pure mustard is labelled "warranted pure;" that which has had its pungency reduced by a small addition of wheaten flour bears the truthful inscription, "This mustard condiment is warranted free from any injurious admixture."

We are now shown the packing-room, where a number of men and boys are performing feats of dexterity, far more surprising than the sleights of Houdin or Frikell. We see a plain sheet of tin-foil suddenly become a shapely case; but the manner in which the lad performs the trick quite escapes our observation. The cases and tins are filled, and then labelled with equal adroitness. The white, unblistered hands of the packers remind us of a peculiar fact connected with mustard. In the seeds or dry flour chemists do not find the acrid principle for which mustard is so remarkable. The flour must be wetted before we can enjoy it as a condiment, or make use of it for a poultice. The pungent, volatile oil of the black mustard, and the biting acrid liquid of the white, both result from the action of water on some of the constituents of the seeds. The fixed oil, which is expressed from the seeds, is quite devoid of acrimony or pungency, and can scarcely be distinguished from rape oil.

We now proceed to another building to witness the manufacture of a by-product. We saw in the sifting room an abundance of what may be called mustard bran—the broken skins of the seeds. This we looked upon as mere waste, but now—to our great astonishment—we observe a number of workmen busily engaged in converting it into manure-cake. The process is interesting and somewhat ludicrous. Several long stocking-like bags are filled with the bran, and then piled one above another in a hydraulic press. The pump is worked, and the well-filled stockings are gradually squeezed flat, while little streams of oil trickle down the press into a reservoir below. The action of the press is now reversed, and the cakes are lifted out one at a time, and handed by the press-man to his attendant. The latter, on receiving one of these flattened limbs, rests it on a support and pulls off the stocking. The leg thus exposed to view is about the size, and has nearly the shape, of a tailor's sleeve board. Having likened the cake to a leg, we feel rather uncomfortable when the workman pares the edges with a knife; but we find that the appearance of the mangled limb is greatly improved by the operation. The cake is now ready for the market, and will fetch a good price, as it forms a valuable manure, particularly for land infested with the wire-worm. The oil expressed from the bran is similar to that obtained from the seeds in the preliminary crushing process. Our conductor now shows us the spacious ware-

house in which the fixed oil is stored, and we here complete our examination of the mustard manufacture.

An immense number of hands are employed at this factory in making the tins in which most of the mustard of the firm is packed. We are shown many labour-saving machines for cutting the metal into the required shapes; and, lastly, we are introduced to a large, well-lighted workshop, in which the operations of shaping, fitting, and soldering the tins are performed.

Leaving this room, we return to the cosy office, and rest awhile before inspecting the Starch Works. To prepare for the new set of impressions, we look over the following notes which we jotted down in our pocket-book before leaving home:

Starch, or Fecula, is one of the most important and widely diffused of the vegetable principles, being found, to a greater or less extent, in every plant. It is most abundant in those seeds which constitute corn and pulse, in certain roots and tubers, and in soft stems. From these sources the starch may usually be obtained by rasping or grinding to pulp the vegetable structure, and washing the mass upon a sieve, which will retain the torn cellular tissue, but allow the fine starch to pass. Potatoes treated in this manner yield a large proportion of starch. From grain, a very fine description of starch may be procured by a similar process. Wheaten flour, when mixed with sufficient water to moisten it thoroughly, forms a smooth, elastic, and tenacious dough. Now, if some of this dough be placed on a piece of muslin, strained over the mouth of a large glass vessel, and be worked with the hand under a stream of water as long as the water passes through milky, there will remain at last upon the muslin sieve a white, sticky substance, called *gluten*; and when the milky water has become clear by standing, a white powder will be found at the bottom of the vessel. From 100 parts by weight of fine English flour, about 70 parts of this white powder, which is pure starch, may be thus obtained. This simple mechanical process is, however, quite obsolete. In manufacturing wheaten starch on a large scale, the raw material is steeped for a considerable period in water, so that the *lactic acid*, always developed under such circumstances from the sugar of the seed, may partially dissolve the gluten, and thus facilitate the separation of the starch. A few years since, all the

starch used in the country was made from wheat, but latterly other raw materials have been employed, the most important being rice. To obtain starch from rice, it is necessary to employ a very dilute solution of *caustic soda* for disintegrating the cellular tissue of the seed. To the naked eye starch presents the appearance of a soft, white, and often glistening powder; under the microscope it is seen to be altogether destitute of crystalline structure, but to possess, on the contrary, a kind of organization, being made up of multitudes of little transparent bodies, generally rounded, upon each of which a series of concentric rings surrounding a central spot may often be traced. The starch granules from different plants vary greatly in magnitude; those from the tubers of the Canna, a West Indian plant, being the largest, and those from rice the smallest. By means of a microscope sufficiently powerful, any kind of starch may be easily distinguished from the others by the shape and size of the granules and the peculiar markings which they exhibit. In the mature grain of rice the granules are densely packed and firmly united; hence the gritty character of rice-flour; hence, also, the necessity for employing such a powerful agent as caustic soda to disintegrate the grain. Though starch be washed again and again in cold water, the granules retain their characteristic form; but when a mixture of starch and water is heated to near the boiling point of the latter, the granules swell and burst, producing, if the proportion of starch be considerable, a thick gelatinous mass. The term *amidin* has been applied to this peculiar jelly of starch.

With this book-knowledge we commence our survey of the starch factory. Though still accompanied by Mr. Colman, we are specially under the guidance of the intelligent manager of this department, whose lucid and detailed descriptions of the various processes prove him to be a master of both the theory and practice of starch-making.

The raw material of this interesting and beautiful manufacture is chiefly rice; the produce of that widely-cultivated grass which botanists name *Oryza sativa*. The small grains grown in Madras and Bengal are usually employed for the sake of economy, but any of the forty or fifty varieties of rice known would yield nearly the same proportion of starch. The rice used in this particular factory is floated up the Wensum, and hoisted directly from the vessels to

the upper story of the building. Here we are shown the coarse Indian bags containing the raw material which we are about to follow through the establishment. Having no desire to descend head foremost down a wooden shoot, we choose a different path from that taken by the rice, and reach the floor beneath by the aid of a flight of stairs. Here we see a number of huge iron cisterns, in which the "liquor," or solution of caustic soda, is prepared. Under these, on another floor, are the vats in which the rice is acted upon by the alkali until the hard grains are rendered so friable they may be rubbed to a powder between thumb and finger. It is cheaper, however, to use millstones worked by steam than to employ innumerable thumbs and fingers for rubbing down the grains. The steeped rice is ground with water, and from each pair of stones runs a continuous stream of the starch material, which now appears as a thick, creamy liquid. Our conductor, in showing us this new product, proudly calls attention to its remarkable smoothness, a quality which bears witness to the perfection of both steeping and grinding processes. He laves his hand in the white stream with evident satisfaction, and raising some of the product in the hollow of his palm, he examines it with the critical eye of an expert.

The creamy product, which contains all the insoluble constituents of the rice in a finely divided condition, is now placed in deep tanks called "separators," and mixed with a large proportion of water. Each tank is provided with a long narrow window of plate glass, through which the contents can be seen; and inside each there is an agitator, to which a rapid motion may be given at any time by connecting it with the train of machinery which runs through the factory. The cream of rice is first agitated in these tanks until its particles are well diffused through the water. The agitators are then stopped, and gravitation is allowed to do the work of separation. The particles of skin, fibre, and gluten slowly subside, leaving the minute starch granules suspended mechanically in the water. When the separation is complete, the starchy water is decanted from the sediment, and pumped up through tubes of gutta-percha to immense shallow vats in the upper part of the building. These vats, which are called "settling-becks," cover a large area, and as they are fixed within a very few feet of the roof, we find our stooping walk around them somewhat fatiguing.

Our two guides get along pleasantly enough, for they know when to stoop and when to walk upright; besides, happily for them, they do not wear chimney-pot hats. On reaching the last of the becks, our practical friend bares his arm and fishes up a handful of the deposited starch, which looks like a mass of fresh curd. He tells us that the settling becks are all lined with zinc, that they are re-filled with the starchy water every day, and that the deposited starch is cleared out twice a week.

The mixture of fibre and gluten left in the separators is sold at a good price as pig-food. As, however, the pig-keepers in the neighbourhood cannot use up the whole of the product, a set of hydraulic presses are constantly at work squeezing this nutritious material into compact cakes, which can be packed in a comparatively small compass, and transmitted to the hungry pigs of remote parts. We are curious to know the nature of the laborious task which is being performed by a dozen muscular men, and are not a little surprised to hear that they are merely "blueing the starch." These men stand round a large tank, and mix the thick starch with the colouring matter by means of large wooden shovels. To look at them from a distance, one might imagine that they were operating upon iron instead of starch, for no blacksmiths ever worked harder. The colouring matter is *smalt*, and it is added in small quantities to the starch paste, until the latter acquires the delicate blue tint which most laundresses admire. Some of the starch prepared at this factory is left uncoloured, for in certain parts of England the pure white product is alone used.

The starch-paste, whether blued or not, is passed through sieves to free it from any accidental grit, and then poured into cloth-lined troughs, like mignionette boxes, to drain and consolidate. When sufficiently hard, the starch is cut into cubical blocks, each about five inches in diameter, and removed from the troughs. Following the blocks we come to a large room around which are arranged a number of hot closets or stoves. The first and largest of these closets is called the "crusting stove," and into this the cubes of starch are carried and placed in regular rows upon the shelves. After having been exposed for some time in this Turkish bath to a temperature of 140° Fahr., the blocks are removed and the surface crust is carefully scraped off each.

The clean blocks are now packed in paper, tied up, and labelled as though they were just about to be sent from the factory.

This operation surprises us, for an important link seems missing in the manufacture. The parcels are familiar enough, but we never remember meeting with a solid cube of starch in commerce. Starch has always been presented to our observation in curious irregular prisms, and we naturally want to see how these prisms are produced. Our practical friend laughs when we communicate our wish to him, and informs us that the starch is "crystallized" after it is packed, merely by exposing the parcels to an elevated temperature for several days. Opening one door after another, he shows us thousands of parcels undergoing the process of stoving; and by breaking open at least a dozen parcels he thoroughly elucidates the mystery of starch crystallization. Taking a packet which has been sufficiently stoved, he unpacks it very slowly and gingerly, so as not to destroy the cubical form of the mass of starch within. The mass which he thus exposes to my view is covered with minute cracks, yet it is a perfect cube for all that. On lightly touching it with the finger it instantly falls to pieces, and where the cube stood we now see a heap of the irregular prisms or "crystals," as they are commonly, but erroneously termed. These prisms are the parts of a dissected puzzle; but we should as soon think of attempting to count the hairs of a well-thatched head as trying to rebuild the cube.

We have now traced the progress of starch from the bag of rice to the packet of crystals, but much remains to be seen before we can take our departure from the Carrow Works. The vast warehouse into which we are now conducted, enables us to form an adequate conception of the productiveness of the starch factory, The packets are arranged in large blocks, between which wide passages are left. In one of the blocks, which has lately been built, we are assured there are 3082 packets, and this is not by any means the largest in the place. We cannot help comparing the piles of starch to houses; and the whole warehouse will live in our memory as "Starch Town," or the "City of Fecula."

Messrs. Colman manufacture the products known as "Blues," which are associated with starch in domestic economy; but at present the seat of this manufacture is Stoke, where they have another establishment. We are in-

formed that there is nothing very curious in the preparation of the blue, which is a simple mixture of indigo and starch.

Though we have visited Carrow solely to survey the mustard and starch factories, we are tempted to take a peep at the great flour mill which has been erected by the firm, and which for magnitude and completeness surpasses every mill which we have hitherto seen. The machinery in this part of the works is driven by a magnificent pair of engines, which together have a nominal power of eighty horse. There are many other interesting steam-engines connected with the works; indeed, a whole day might be well employed by one with a mechanical turn in merely examining the different sources of power. A fine pair of beam engines, with the nominal power of fifty horse, work the shafting or starch factory; another pair gives motion to the pestles and sieves of the mustard factory; and a very odd-looking oscillating engine is connected with the machinery of the principal workshops.

In a detached building near the offices we are shown another kind of engine, which the Messrs. Colman will endeavour to keep from working as long as possible, though a staff of well-paid servants are attached to it; this we need scarcely say is a fire-engine. Around the room in which it is kept are arranged the lengths of hose which might be required, with torches, buckets, and a complete set of fire-proof dresses. The measures which have been taken to oppose the destroying element are admirable. Water-pipes ramify in all directions through the establishment, and are furnished with cocks of the most improved construction.

An immense quantity of good water is used in the starch manufacture, and to increase the supply the enterprising proprietors of the works are now sinking an Artesian well. Already the astonishing depth of 1200 feet has been reached by the boring tools, and the engineers confidently expect to come upon the green sand and soft water before long.

There is a paper-mill which also claims attention; but we dare not stop to examine the beautiful machinery which belongs to it, for time flies, and we must reach London to-night. In our hurried walk over the works, we come upon coopers' and engineers' shops, a smithy, a steam saw-mill, and many other important adjuncts to the

triple factory for Mustard, Starch and Flour. We are not astonished, therefore, when Mr. Colman informs us, that no less than six hundred people find constant employment on these great works at Carrow.

MESSRS. HILL, EVANS AND CO.'S VINEGAR WORKS AT WORCESTER.

Away from the smoke and din of Birmingham, by the morning train into the fresh open country—past fields, and hedgerows, and quiet homesteads, beyond the little quaint station of Droitwich, the soft green landscape, broken in the distance by hop-gardens, where the first green shoots are peeping out ready to climb the tall, brown, bare poles—by apple orchards, where the dripping trees will soon burst into masses of delicate blossom under the influence of the genial warm spring rain. Our mission is in the old city of Worcester, that "faithful city," whose name, denoting as it does, the site of a Roman tower, recalls the various eras of a nation's history, from the time of its possession by a British bishop, and its inclusion in the kingdom of Mercia, under Penda, in 625, to the last great struggle beyond its old cathedral walls, when the Royalists succumbed to the stern Puritan, who watched the tide of fight from the steeple of the little church across the river.

Twice has Worcester been the seat of civil conflict between the people and the monarch, and on each occasion has it stood out the siege in favour of royalty, till it could stand no longer either against bold disaffected barons, or the soldiers of the Commonwealth. Twice burnt down between 1113 and 1133, almost utterly ruined in the civil wars of Stephen and of John, who made it his favorite retreat, and there submitted to the synod which led to the institution of the Great Charter, taken and burnt again by Owen Glendower in the reign of Henry IV, mulcted as a matter of course by Henry VII, suffering from earthquake in 1534, and pestilence in 1558 and 1637, it must have possessed rare vitality to play so strong a part five years after the latter date, when Prince Rupert tried to keep it against the army

of Cromwell. Nearly three hundred years ago it held its own, and its trade flourished even as it does in our happier and more peaceful time. "The wealth of the towne of Worcester," says old Leland, "standeth most by drapering, and no towne of England at this present tyme maketh so many cloathes yearly as this towne doth." With which reflection, our wandering fancies being recalled to such of our own "cloathes" as are being gradually soaked by that spring rain which seemed so mild and genial when the lover of nature was under shelter, we hail a return fly, and set forth to explore the vinegar-works of Messrs. Hill, Evans, and Co.

Why it should be necessary to go either through a church or a newly-built parochial school on our way to the manufactory is not quite clear; but, as we stand at the door of the building to which we have been directed, and notice its red brick and white facings, its pointed roof, its large windows, its swinging half-glass door, and, above all, its extreme cleanliness (to say nothing of its size), we feel that there must be some preliminary ceremony of this kind to observe, and rub our shoes very carefully. Furtively peeping through that same glass door, however, we discover that this building is the counting-house—that the space which should be occupied by pews is filled with long and and shining desks—that instead of a "dim religious light" there are more windows in the roof, which throw everything into strong relief, and that the semi-ecclesiastical style of architecture is admirably adapted for business purposes. Not remaining here long, however, we are delivered to a patient guide, who informs us as we cross the yard that the manufacture of British wine was introduced at Worcester between eighty and ninety years ago; that Messrs. Hill, Evans, and Co. purchased the business in 1829; that it was, at that time of very limited extent, but has now so greatly increased as to place the firm upon an equality with the oldest and largest manufactories of British wines in the kingdom.

Compared to the vinegar-works which were established by the firm in 1830, the manufacture of British wines in which these gentlemen engage scarcely seems extensive; but taken alone it affords some scope for reflection, since the vaults in which are stored orange, ginger, raisin, cherry, currant, and the rest, are of very great extent, lying, indeed,

beneath a large portion of the warehouses above, and consisting of eleven avenues, some 240 feet in length, and capable of containing about 3000 butts or pipes of assorted British wines. The process of manufacturing the wine is not a complicated one, since the fruit having been once steeped, fermented, and pressed, it is only required to store and give it age and maturity, when it is fined ready for sending out.

Although Messrs. Hill, Evans, and Co. originated the manufacture of vinegar in 1830, it was evident that there were vinegar works in that city at a very much earlier date, since their present establishment includes the site of two small manufactories; and a row of about twenty houses, called Vinegar Row, has lately been pulled down by the firm to effect a public improvement. From the immense cellars of British wine we proceed at once to the inspection of the operations in the larger manufacture of vinegar.

Requesting that we may "begin at the beginning," and finding that the beginning is grain, we cross a yard where the new red brick buildings rise story above story like dock warehouses, and are taken to the granary floors, of which, beside the basement, there are three, together capable of containing some 8000 quarters of the grain from which vinegar is composed. To the topmost room this grain is first hoisted by means of a crane, and, through traps in the boards, is afterwards shot into the lower floors, where heaps of barley and sacks of malt lie in all directions ready for unnumbered brewings.

The first process to which the grain is subject is, of course, grinding, and for this purpose it is taken to a floor where three great wooden "hoppers" receive respectively oats, barley, and malt, and conduct them to the receivers of the mills below—mills formed of the ordinary circular stones revolving one upon the other in protecting iron boxes, and each furnished with a lever, by means of which the stones may be raised, for the purpose of cleaning and repairs. From these slowly-revolving inveterate mills the crushed grain falls in flakes, hot with the friction, through metal shutes, into a wooden trough, which runs the entire length of the room below. Through this trough passes a sort of endless band, furnished on its upper side with little open pockets, which, as it passes through the meal, fill themselves, and carry their contents up again, through a

wooden shaft, there to empty themselves into another trough provided at the bottom with canvas funnels, beneath which are placed the sacks for filling, the meal being pushed along the channel by means of a revolving bar furnished with flanges at regular intervals. These operations, as well as some others yet to be described, are effected by means of steam power; and, in keeping with the scrupulous cleanliness which characterises the whole establishment, we notice that the engine-room, through which we pass to the meal-room, is a large apartment in which there is nothing except the necessary appliances for working the engine. The engine itself looks like a highly-magnified working model of some mechanical improvement, and is so bright and carefully kept that even the engine-room of a crack steam-yacht might suffer by comparison. It is of forty-horse power, and is constructed on the high pressure principle; but we are surprised that there is so little noise, and miss the usual clang and rattle of steam machinery, a circumstance partly accounted for by the fact that one of the driving-wheels is of wood and the other of iron.

The full sacks are now removed to the meal-room, and beneath the meal-room, elevated on a timber stage or platform, and accessible by wooden steps leading to a surrounding gallery, stands the great mash-tun, surrounded at some distance by vats which are filled with water from a large main tank. On ascending to witness the first actual process of vinegar making we are forcibly reminded of the great tun at Heidelberg, which lies amidst its wooden beams and supports in a manner not dissimilar. Early in the morning the brewing commences; the tun is partially filled with water, and receives the meal through the shutes in the floor above. About 384 bushels of barley, 68 bushels of oats, and a like quantity of malt, in all 65 quarters of meal, is sufficient for a day's brew; and this, taking up the water, forms a "gruel thick and slab," to which is added some water heated by means of steam-pipes passing through the vats. Four times, and each time at an increased temperature, must this be added before the brewing is complete. While it steeps and seethes a series of rakes, with flanges something like those of a paddle-wheel, revolve on a bar which crosses the tun, this bar itself revolving on an axis as though the whole concern were a sort of rude orrery adapted to a mechanical purpose. Over the whole surface of the

seething liquid lies a great, dense, white, yeasty flake, and a pleasant odour arises which bespeaks the richness of the brew. As soon as the strength has been thoroughly extracted the operation is complete, and the liquid portion of the mass is run off into tanks below. This liquid—aromatic, sweet, and gummy—is indeed "sweet wort," with all its insidious property of intoxication. By this process the sugar and the diastase (formed in malting from the starch and the gluten of the grain) are dissolved, and the latter substance, acting on the starch of the grain not malted, changes it first into a species of soluble gum, and, finally, into saccharine matter. We have now to follow the operations which convert the sugar into alcohol by vinous fermentation, a task which involves a steady climbing of wooden stairs, and an amount of personal exertion which nothing but an intense interest in the subject could render endurable, for from the tanks into which it has been run from the mash-tun the wort is pumped through large copper pipes into an enormous tank which stands on the roof of the building, and is itself covered at some height above it by a raised roof of its own, supported by pillars, and leaving it open to the air all round. This is the "receiving tank," and, after having paused a moment to take breath, and a bird's-eye view of the neighbourhood at the same time, we venture to look into it, and see the wort which has been pumped in lying under a light snowy froth. The way up has led along wooden galleries, intersected by great water-tanks, and, looking fearfully down into the floors which lie below, we prepare to retrace our steps. From the receiving-vat the liquid is allowed to run in pipes through the refrigerators, a series of tanks containing cold water, from which it at last escapes into the great shallow cooler which is sunk in the floor of the upper story, and exactly resembles a swimming-bath, except that there are no boxes for undressing, and no bundles of corks floating on its surface. This bath is about 60 feet long and 30 feet wide, but only a foot in depth; and, instead of windows, the upper part of the walls next the roof is formed of open lattice-work. The temperature of the wort on leaving the receiving-cistern is about 100°; by the time it leaves the last refrigerator it is reduced to 78°, and it remains in the bath until the temperature is about 63°. Its specific gravity is then 55°. Immediately under this great bath or tank lie the fermenting-vats, of which there

are eight, each holding some 16,000 gallons, and, the wort once run into these, the barm is thrown in and the fermentation commences, the gravity falling to 0 if the operation is successfully conducted. The final process of acetous fermentation now claims attention, and we once more mount by fresh flights of ladder-like steps to the acidifying rooms, where two stories of enormous vats stand in tiers, divided by brick partitions and accessible by a gallery or platform of timber. Into these vats (and there are thirty of them, holding from eight to twelve thousand gallons) the wort is thrown by pumps which force it through pipes running underground. Nearly one half of each vat (from the top downwards) is occupied by large bunches of besom or birch-twigs, upon the surface of which the wort is continually splashed and thrown by means of another arrangement of pumps which wait for its arrival from below. The reason of this is sufficiently obvious—acidification being effected by the combination of alcohol with the oxygen of the atmosphere, and the great exposure necessary for complete oxydation being secured by the large surface presented by the bunches of besom through which the air passes freely. In the old process of acidification, besides admixtures of sulphuric acid—presently to be more fully explained—it was customary to expose the vats of wort in large, open spaces, called vinegar fields or yards; but, as well as being less efficacious and slower in its operation, this led to considerable waste of the acetic ether, which even here is escaping with such pungent odour that we seem to have been suddenly confined in a gigantic "vinaigrette," and feel as though we should have an immunity from faintness and sudden headache for the remainder of our lives. Even under the improved system adopted by Messrs. Hill, Evans, and Co., the acidification is by no means a rapid process, since it takes nearly a month of this exposure to effect the chemical change which converts the liquid into unfined vinegar. Hitherto our attention has been divided between "machinery in motion," fermentation, tuns, pumps, cisterns, and vats, which we have been led to describe by the term "enormous." We are now led into a great range of warehouses, where everything is still, quiet, cool, and almost solemn—led to the contemplation of a fresh series of vats of such dimensions that the "three men in a tub," of nursery celebrity, become mere miserable pretenders before about thirty huge crec-

tions of hoops and staves capable of forming roomy barracks where "the butchers, bakers, and candle-stick-makers" of Worcester might find accommodation. Of these the first half-score receive the vinegar for the purpose of "fining," and to this end contain a small quantity of beech-chips, which aid in clarifying the vinegar. Each of these vats will contain 18,000 to 20,000 gallons, and are a fitting preparation for their brethren, whose stupendous bulk is devoted to storing the vinegar in a department called the "filling-room." These latter receptacles are in reality as large as houses, and cost as much to build. As we gaze at them in utter astonishment, we make a calculation that it would be possible to convert the smallest of them into an eligible villa residence, and so move off comfortably to Australia on board the Great Eastern in complete and undisturbed security. To say that the least of the twenty monsters holds 10,000 gallons, and that the five largest will contain 80,000 each, is saying little, for mere figures give but an inadequate idea of space; it is, perhaps, more to the purpose to remark, that on the completion of one of the smaller size a party of four-and-twenty sat down to tea within its timber walls, and that the area of the larger would afford ample accommodation for half-a-dozen fashionable "kettledrums."

Certain proceedings which have occurred within the last six years in connection with evidence upon chemical analysis have somewhat mitigated the public confidence not only in those once valuable certificates which declare certain articles to be "entirely free from adulteration," and are signed with the names of self-constituted investigators, but also in the complete infallibility of some analytical and sanitary commissioners publicly appointed for the purpose of official representations. While there was a great and urgent necessity for some such public appointment, however, the inauguration of an analytical commission was popularly regarded as a deathblow to all adulteration whatever, and not fully appreciating how delicate a scientific matter this same chemical analysis sometimes is, a large number of honest people delivered their opinions entirely to scientific guidance, and were prepared to take the word of the commission on every case in which they announced the results of their inquiries. This was doubtless a reasonable course enough, when we consider the nature of the subject; but, like many other useful institutions, the commission

were occasionally at fault; and an opinion somewhat precipitately expressed led, in more than one instance, to results which bore hardly upon individuals at whose expense the mistake of the learned body had been made. It so happened, that some ten years ago the sanitary and analytical commission of that celebrated journal, the 'Lancet,' made some such statement of opinion with respect to the vinegar manufactured by Messrs. Hill, Evans, and Co.; and though, with a proper sense of justice, the charge of using sulphuric acid (which was the assertion originally put forth) was afterwards withdrawn in the pages of that journal, the firm believed it to be a matter of sufficient importance to their own character and commercial interests to need complete and separate refutation. To this end they induced Professor Graham, Dr. Hofmann, and Dr. Lyon Playfair, three gentlemen whose scientific attainments were considered to be beyond dispute, to conduct a special analysis of their vinegar, and at the same time gave them free access to the books and journals, which recorded the transactions of the firm for the previous twenty years. The result of an examination of these books and of the analysis of several samples of the vinegar taken from vats selected by the operators themselves, was a declaration that the mode of oxydising the alcohol adopted by Messrs. Hill, Evans, and Co. is rapid and effective, and appears to have the incidental advantage of changing and rendering insoluble certain glutinous and albuminous matters in the fermented wort which are apt, if not got rid of at this stage of the process, to occasion after-muddiness in the vinegar and to prevent its keeping;—that it was generally considered necessary in the vinegar trade, at a former period, to add a small portion of sulphuric acid to vinegar in order to counteract this tendency of the liquid to decomposition, and to preserve it from turbidity (this addition of sulphuric acid was permitted to the extent of one gallon of sulphuric acid to one thousand gallons of vinegar by an excise regulation, and had, therefore, a legal sanction);—that sulphuric acid is now known to be unnecessary in properly-prepared vinegars, although still added by some manufacturers for the purpose of increasing the strength of their vinegar, or, in some instances, merely from habit and the indisposition to disturb the routine of an old-established practice;—that the presence of sulphuric acid in vinegar should be looked upon as the mark of

inferior quality, for it is only where the mode of manufacture is defective that the addition appears to be at all necessary;—and finally (after detailing the course of their experiments), that the vinegars of Messrs. Hill, Evans, and Co. demonstrate themselves to be pure malt vinegars, wholly unadulterated with sulphuric acid; while, on the other hand, their strength is not artificially enhanced by the addition of pyroligneous acid, sometimes practised, and which would betray itself by an odour of creasote when the liquid is heated, of which these vinegars are entirely free. Notwithstanding the distinct withdrawal by the 'Lancet' of the imputation erroneously made, and the unanswerable report of Professor Graham, Dr. Hofmann, and Dr. Lyon Playfair, and the *amende honorable* made by the 'Lancet,' however, Messrs. Hill, Evans, and Co. for some time continued to suffer under the imputation originally put forth, of which a very damaging use was made by some of their rivals in business, even after its complete withdrawal; they were, however, convinced that truth would ultimately prevail, and in this they have not been disappointed, for their annual sales have continued to increase year by year, so that, while the quantity for 1852 (the date of the analysis) was 426,516 gallons, that for 1859 (we are informed) stands recorded as 1,208,600 gallons, a quantity which will indicate that Messrs. Hill, Evans and Co. are the largest manufacturers of vinegar in this country.

The vinegar in its pure state is of a pale-straw colour; but, as there is a fashion in these matters, and the British public prefer the usual brownish tinge, the colouring is effected by means of burnt sugar. On the other hand, our Scottish neighbours object even to the natural hue, and the vinegar supplied for the northern trade has to be so distilled that it may be rendered perfectly white.

Having left the store-vats and the filling-room where the vinegar is drawn off into casks, we pass into the cooperage, on our way back to the counting-house. Stacks of casks from the ground to the high ceiling; piles of staves, traps and pitfalls of hoops, a continual sound of spoke-shaving and hammering show that the work is going gaily on. But we have not yet done with the vinegar; for it remains for us to see it put to one of its most legitimate and principal uses, and in a manner which is in some sort a guarantee of its excellent quality. In truth, the well-known Pickle, Pre-

serve, and Sauce Manufactory of Messrs. Lewis, Webb, and Co. is so near the Vinegar-works that it seems like a natural supplement; and we go there at once to continue our observations by noting the practical application of all the processes by which we seem to have been malted, ground, mashed, heated, fermented, cooled, alcoholised, acidified, fined, and stored. Indeed, Messrs. Lewis, Webb, and Co. have contracted with their neighbours to use no other vinegar than theirs for the pickles made in their warehouses; and they adhere to the principle of non-adulteration by steadily disregarding that artificial brilliant green colour in the pickled vegetables which is only to be obtained by hurtful ingredients.

Here in a great yard, which is, in fact, a sort of open wharf, lie casks full of cucumbers, cabbages, onions, and all the variety which are combined in the "mixed pickles" of ordinary domestic economy. They are being steeped in brine, previous to the first pickling in spice and vinegar, which precedes their being bottled. A cucumber of pale yellowish green, which is undergoing this first pickling, is already beautifully crisp and cool, and the difference between the results of using the ordinary admixture of pyroligneous acid and vinegar and the pure malt vinegar is detected instantly by anybody who has been unfortunate enough to taste the former compound.

We have little time to spare, however, and, passing through the large warehouse where women and girls are filling the various bottles, and out by the room where preserved fruits are in their preliminary stage, simmering in steam-jacketed electro-plated pans, we bid farewell to Messrs. Lewis, Webb, and Co.

As a *finale* to our visit to Worcester and its vinegar-works, we call on Messrs. Lea and Perrins, the manufacturers of the celebrated "Worcester Sauce," are conducted by one of the firm through the works, and learn that hundreds of gallons of the vinegar manufactured by Messrs. Hill, Evans, and Co. are used in making this famous condiment, of which the public consume 2000 dozen bottles per week, while the firm pay over £4000 per annum for the bottles in which the sauce is sold. And so, with brief but not insincere compliments, we take our leave, and, after coming into a liberal reversion of the Severn salmon provided for the early market dinner at the Crown Hotel, fall into a doze and,

in a confused mingling of "the antiquities of Worcester" with Messrs. Hill, Evans, and Co.'s factory, dream that Hannibal, in an attempt to sack the city, discovers that his commissariat arrangements are unequal to the task of conveying to the Alps an eighty-thousand gallon vat of pure malt vinegar.

MESSRS. ALLSOPP'S PALE ALE BREWERY, BURTON-ON-TRENT.

The history of ale is in some sense the history of England, and the statistics of its consumption would afford to the curious inquirer an indication of social and political alternations.

It may be doubted, indeed, whether an extended account of the origin and progress of the great beverage in all its ancient and modern varieties would not include voluminous annotations on that famous "History of the World," the author of which lived in an epoch when the art of brewing had reached, if not its culmination, at least a degree of perfection which was in itself no slight addition to the glory of the age.

For learned disquisitions, however, upon the "cerevisia" of Pliny, the "cerealis liquor" of Plautus, or the "zythum" of Columella, we are not at present inclined; moreover, in the space devoted to this article the "guol" of the feast of Thor, the later "eal," the unhopped Witsun ale of our Saxon forefathers, the "chica" or maize beer of ancient South America, the "bouza" (ominous name) or millet beer of the Crim Tartars and the Lower Himalaya, the Russian "quass" or rye beer, the "ava" of the South Sea Islands, and that wonderful "koumiss" which the Tartars make from mares' milk, can receive no scientific investigation.

Through the whole course of our ballad literature, however, the hearty praise of ale (that which we call beer having been a subsequent introduction, if not an unwarrantable innovation) rings out in numbers tuneful and jovial, with plenty of good old suggestive titles, from "nut-brown" to "nappy."

From Bishop Still, whose orthodox utterances in favour of the honest liquor exhibit a generous acceptance of either "new or old," to the grand old "waterman," John Taylor, who rowed in a wherry from London to York, down the Thames, the Trent, and the Humber, drinking ale all the way, what do we not find in its praise? Then, have we not the Hagamena songs and "Sir John Barleycorn," and a host of others, in which the keynote is ale and jollity?

If the history of ale is the history of England, however, it may be said that for the last two hundred years the history of the Allsopps is the history of that glorious brewage of Burton which still bears the palm amongst all other ales. The ale of Burton, indeed, has been celebrated from an antiquity too remote to trace with certainty; but its consumption was principally local, not extending much beyond Derby, until 1623, when it was first introduced into London under the name of "Derby Ale." In our own time the name of the old family of Burton brewers seems likely to remain identified with the beverage, since "a glass of Allsopp" is an every-day request which the publican thoroughly recognises, however he may fail to comply with the demand by serving the genuine article.

All these things, then, make it necessary that we should, in the interest of this series of English worshops, pay a visit to the old brewery at Burton whence Messrs. Allsopp supply that "pale" ale whose sparkling amber fills the glasses of thirsty Britons, both here, in India, and in the tropics,—whose fresh but mellow ripple now gurgles from cool black bottles in every Parisian restaurant where beer has till lately been unknown except in the state of a stale and flabby beverage which failed to compete with thin "ordinaire."

The Burton ale, however, long before it had become common even in London, was largely appreciated in Russia, where the exportations were welcomed not only by the gentry, but, if the chronicles of the time be reliable, by the Empress Catharine and the rough ship-building Peter, in whose orgies the strong mellow beer of this English brewery—then in the hands of the predecessors of Messrs. Allsopp—held as high a place as, from its sanitary properties, it well deserved. "As soon as one sits down," says an eyewitness of the Court festivities of the Czar, "one is

obliged to drink a cup of brandy, after which they ply you with great glasses of adulterated tokay and other vitiated wines, and, between whiles, a bumper of the strongest English beer."

In 1806, however, the Continent was closed entirely to British commerce by the decrees of the Emperor Napoleon—a change which, while it exercised little influence on the other breweries in Burton, completely destroyed the large Baltic trade of Messrs. Allsopp by stopping their exports to Northern Europe. This necessitated an increased attention to the means of creating a large home consumption, and the energy which had for so many years built up the house was still active in extending the knowledge of the virtues of Burton beer from the surrounding districts to the metropolis. This turned out to have been a wise policy, for when, in 1813, the reverses of Napoleon commenced from the battle of Leipsic, and Messrs. Allsopp endeavoured to regain their export business, it was found that during the stoppage of the supply tastes had changed, and the demand had so greatly decreased that the trade never recovered its former importance. Although in 1820 the new Russian tariff removed all the prohibitory duties, and the Russians refused to receive any ale which did not bear the distinguishing brand of the house, another tariff was issued in 1822 which again imposed an almost prohibitive duty on English ale, but by a strange omission English porter was excepted from the tax, a fact to which it is said Messrs. Barclay and Perkins may attribute a rise in their fortunes, since it enabled them to acquire almost a monopoly in the supply of porter to Russia. It was in the same year, however, that Mr. Allsopp determined to brew a description of ale peculiarly adapted for the London market; and, after careful consideration, this was effected by adding to the fine aroma and flavour of the original beer a greater degree of hop bitter, while a more neutral taste which enabled it successfully to compete with porter was at the same time obtained.

It was at about this period that a trade arose, however, which soon compensated them for the loss of that of Russia. This was no less than the introduction to India of that pale ale which has since become so celebrated. The first ale of this sort brewed in Burton was the result of an accidental question to Mr. Allsopp from an East India director, who

asked why he did not make an attempt on the Indian market, at the same time showing him a sample of the pale ale at that time exported. The result was that an experiment was first made by a decoction of differently-dried malt and variously-adjusted hops—the first brewage of pale ale having been, in fact, effected in a teapot in Mr. Allsopp's counting-house at Burton.

Through the golden cornfields studded with bright scarlet poppies, on the way past Tamworth and Drayton Manor, the four hours' railway journey from London brings us to that fertile valley where the ancient town of Burton lies upon the silver Trent, set amidst the slope of wooded hills facing that tract of green and fertile country through which the river is shining like a silver band upon an emerald velvet mantle. This simile, which is neither new nor graphic, may possibly have been suggested by the old bridge of thirty-six arches, standing upon which the wayfarer dreams of the days when John of Gaunt kept his Court in the town; of the Abbey Church of St. Modwen, where the nurse of Alfred the Great was buried, and gave her name to St. Modwen's Well; of the battle of the Roses, fought upon Burton Bridge; of that later and, perhaps, more terrible conflict between Cavaliers and Roundheads. But we have little time for dreaming, and the recollection that in these past scenes of English history the family of the "Allsopps of the Dale" figured more or less, brings us back to the object of our visit.

We have already (from the railway station) seen the "new brewery,"—its immense yard piled with whole acres of casks and barrels, but it is the old brewery in the High-street that we are about to visit. The existing building, which was erected in place of the original one in the present century, extends over a considerably larger space than it did even at the time of its erection, for necessary additions, in consequence of the great increase in the trade, have extended its area to several acres; and when it is considered that the new brewery, and the other branches of the establishment, with which this is connected by private lines of railway, employ about 1000 men, that beside the 245,000 casks already in use, 30,000 are made annually, and that during the brewing season the copper fires consume at least 100 tons of coals a day, the increased importance of the Burton ale trade may be better understood.

Entering from the High-street, we are at once introduced to the "master brewer," than whom we can have no better guide through this vast establishment. Whatever may be the meaning of the old saying that "any old woman can brew," it assuredly cannot signify that any old woman can brew *well;* and is probably meant to indicate that only an *old* woman can accomplish a result which requires years of experience to bring it to perfection. To illustrate the method by which practice and theory go hand in hand in the business, it is only necessary to refer to the water used for brewing, which, although the Trent runs at the very doors, is supplied by wells, one of which at the new brewery is only 30 feet in depth, but 40 feet in diameter. This was constructed under the direction of Mr. J. F. Woodhouse, C.E., and is a remarkable result of engineering skill, since the wall, which is three feet thick, was built on the surface before sinking the shaft, so that, the soil being gradually removed from beneath, the entire pile of brickwork descended by its own weight to the required depth. This well will discharge at the rate of 18,000 gallons an hour: it is the largest in diameter of any well ever sunk, and it has long been known by experience that, notwithstanding its comparative hardness, the water is superior to river water for brewing purposes.

In the topmost floor of the brewhouse, to which we are first conducted, the malt is stored previous to its being ground, the grinding or crushing being effected in a mill. From this mill, which is capable of bruising 300 qrs. to 400 qrs. of malt a day (sufficient to brew 32,400 gallons), it is carried by means of an Archimedean screw to the malt-hoppers, whence it falls through shutes into a horizontal cylinder, inside which revolving rakes mix it intimately with the water as it passes on its way to the mash-tuns on the floor beneath. In these mash-tuns, of which there are ten, it remains for some hours, when the "wort," as the liquor is now called, is suffered to run through a false bottom perforated with holes into the "underback," during which journey the malt is "sparged" by jets of hot water passing over and through it from revolving horizontal pipes, resembling the perforated pipes of the London watering-carts. This process extracts the remaining saccharine from the malt. The coppers occupy a large and lofty building; for there are six of them, each capable of

containing 2500 gallons, and under the same roof two hot-water coppers, of 13,000 gallons each, supplying the mash-tuns, they themselves being charged from a great tank as large as a metropolitan swimming-bath, and with a supply of water pure as crystal. These great water-coppers are provided with immense dome-shaped covers, while those which receive the ale are left open for the purpose of facilitating evaporation. During the brewing season these coppers produce about 50,000 gallons of ale daily.

Into the coppers the wort is pumped from the underback, with the addition to each copper of wort of a suitable quantity of hops—a light mass which lies on the surface and does not readily become saturated with the fluid until it begins to boil and forces its way through. Then, however, it bubbles up into great flakes of foam, dense, and charged with odorous gales, which rise around us as we look warily into the seething depths. When the boiling has effectually extracted the tonic and other virtues of the hops, the wort in its improved condition is conveyed by tinned copper pipes to the "hop-back," a large reservoir holding more than 4000 gallons, and about four feet deep. This "back" is provided with a false bottom composed of perforated metal plates, which forms a strainer, separating the hops from the wort. In the new brewery the latter is now pumped into the coolers some 90 feet above. These coolers, which occupy the upper floor of the brewhouse, are simply a series of large, shallow tanks, from 100 feet to 120 feet long, 40 feet wide, and 8 inches deep, lined with Minton's white porcelain tiles. The timber framework which supports the lofty roof of the cooling-room is filled in with louvre boards, a sort of Venetian shutters, which can be so adjusted as to regulate the temperature. The cooling process is more rapidly effected in warm weather, however, by the use of Riley's helical refrigerator, a series of small pipes immersed in a constant supply of cold water. From the coolers the wort finds its way to the "squares" (square vats of about 3600 gallons each) or fermenting-tuns on the floor below; there are sixty-four of these vats, and, upon their receiving the wort a quantity of yeast is thrown in to induce fermentation. When the wort has reached a certain stage of attenuation it is once more run off to the "union casks," a series of casks occupying an entire floor, both in this and in an adjoining building; there are 1200 of these casks, each

containing 160 gallons, and they are suspended in double rows (in such a manner as to admit of their revolution on their axes) in frames at about three feet from the ground. In these casks the ale becomes bright, since the yeast is gradually separated from it and escapes by pipes shaped like a swan's neck, and reaching from each cask into a trough above. The entire length of the union floors must be, at least, the eighth part of a mile, and, as we stand at the entrance, we are peculiarly conscious of the spotless cleanliness of floor and casks—a state of things which is characteristic of the whole place, but seems here to reach its utmost point. The fermentation completed, the beer, bright and clear, is run into the "racking-squares," or vats, upon the basement floor; and here a company of men whose athletic proportions and mighty strength bear, do not let us say "striking," but working, testimony to the effects, both moral and physical, of good ale, are engaged in filling the casks, destined for every civilised community where such virtues are recognised.

Everything here, indeed, is on a large scale; even the gasmeter, which is almost as big as a hogshead, seems to partake of this necessity; and at the new brewery, where we are taken to see the malthouses, we are shown, beside the well, a vat-room containing twenty-six vats, of 11,000 gallons each. Having a sudden desire to become brewers, and reflecting on the extent of our resources, it is some comfort to learn that there is a standing rule against receiving apprentices, notwithstanding that large premiums are frequently offered. The master maltster, who is just the sort of man that a master maltster ought to be, conducts us over the malthouses, a long range of buildings, large enough to lodge a greater number of emigrants than have often gone to form a colony. Beside these buildings in the brewery-yard, however, there are eight or ten more at Grantham; and even these are insufficient to supply the necessary quantity of malt, so that Messrs. Allsopp have to add to their own stock by purchases from the Nottingham, Beccles, and Newark maltsters. In each malthouse a tank of 75 feet long, 9 feet wide, and 3½ feet deep, will contain 1280 bushels of barley, and the 5760 gallons of water in which it is steeped for about fifty hours, to prepare it for germination. From these tanks it is removed to the "frames," or large troughs, where it is gauged by the revenue officers for the

purpose of charging the duty; after which it is spread over the floors of the malt-rooms in various thicknesses. Some of these floors measure 15,000 square feet.

According to the season of the year, the barley remains from ten to fourteen days for the development of the acrospire, or germ, which would ultimately burst from the envelope of the seed, a result which is arrested by the drying on the floors of the adjoining drying-kilns, where the barley is once more spread upon the flooring, in this instance composed of perforated tiles, beneath which furnaces are so arranged as to distribute a regular degree of heat. After four or five days' drying the malt is formed, and, being afterwards cleaned of the "coons" or roots which grow out during germination, is ready for the brewer. The quantity of malt or malted barley which forms the stock at the commencement of the brewing season represents a considerable fortune; while in the barley stores, which are mostly on the top floors of the malthouses, we see thousands of quarters of grain, thoroughly clean, and divided into heaps of such exact size that it would seem as though some arithmetical enthusiast had counted out each grain upon the white and almost polished floor.

The hop stores, across Horninglow-street, are a long range of buildings, at the entrance of the cooperage-yard; and here we walk through a narrow passage on one side of the store, which is all the space that can be afforded, drinking in air charged with tonic, if not with sedative, properties. The stores contain altogether about 2000 pockets of hops, or sufficient for four weeks' consumption during the brewing season. To facilitate the enormous traffic resulting from their increasing business, Messrs. Allsopp have constructed nearly five miles of single lines of railway on their own premises, which are thus connected with the company's termini at Burton. About 300 railway trucks are required for the daily traffic.

The cooperage, for which we have little time left, is not the least wonderful department of this gigantic undertaking. Several hundred men are employed here in making, cleaning, and repairing casks and barrels, the staves, &c., of which are cut from Baltic oak by steam power, and afterwards steeped in a tank of water in order to extract the sap which will remain even in long-stored timber, and would seriously injure the ale. This flavour is (I am told) often the

origin of that peculiarly nutty smack discovered even in inferior sherries. These cleansed staves are afterwards stored in the yard until they become well seasoned, and are ultimately made into casks, of which there are several large pyramids, while the stock of timber is seldom worth less than £30,000 to £40,000. Both new and returned casks are thoroughly steamed and dried in order to prevent the slightest taint; the drying is effected by a current of hot air forced into the bunghole by a fan in connection with a powerful engine. Besides the coopers, however, there are here employed blacksmiths, carpenters, wheelwrights, turners, and engineers, making the entire scene resonant with the sounds of their avocations. More than 1000 casks are here manufactured every week, while as many as 2000 old ones are examined, cleaned, and repaired every day. Twenty steam-boilers are necessary for supplying the requirements of the breweries, with which are connected eleven engines of from four to forty horse power.

And so to finish our visit with a flagon, upon whose edge the bubbles come purling up from the bright liquor below. Truly, says one of those old ballads sung at the churn suppers—

> This ale it is a gallant thing;
> It cheers the spirits of a King;
> It makes a dumb man strive to sing—
> Ay, and a beggar play!
> A cripple that is lame and halt,
> And scarce a mile a day can walk,
> When he feels the juice of malt
> Will throw his crutch away.

We have not yet done with Messrs. Allsopp's ale, however. Personally, indeed we don't desire to have done with it for many a year; but on arriving once more in London we pay a supplementary visit to the immense metropolitan stores at Camden Town, Haydon-square, and Poplar. At each of these depôts lie thousands of those casks which supply the consumption of the great city and the foreign markets. How many of these are consumed by thirsty visitors to the various London exhibitions we are not able to tell; but it is certain that the enormous accumulation at the places to which we now make a hasty visit, and where the drays come and go every day and all day long, will furnish to representatives from all England samples of the brewing of the old town upon the Trent.

DOMESTIC WORKSHOPS.

The Boar's Head Cotton Mills, Messrs. Evans and Co., Darley.—The Gray's Inn Pianoforte Manufactory.

DOMESTIC WORKSHOPS.

THE BOAR'S HEAD COTTON MILLS, MESSRS. EVANS AND CO., DARLEY.

ENGLAND has but just passed through a great pain; and is still disturbed by a wearing anxiety for the sufferers whose anguish she has watched with such tender solicitude. Hundreds of men and women have waited—God knows with how much patience and self-restraint—beside the silent Lancashire mills, while the inquiring eyes of statesmen, manufacturers, and philanthropists, were directed with more or less of honest earnestness, to new regions, whence they might obtain a supply of that staple, the manufacture of which was so long regarded as indicative of national prosperity. No longer counting on the millions of cotton-bales which came each year from the low sandy islands on the coast from Charleston to Savannah (the sea island cotton with its long silky filaments), from South Carolina and Florida; from the uplands of Georgia, and all the pod-producing tracts of that vast continent; we must look to new districts in the hope to recover, from a fatal dependence on the supplies of one country.

These reflections—which are, indeed, but a continuation of the remarks at present pervading all companies where the great topic is mentioned—occur to us while we prepare to visit one of the large mills which are still supplying the world with cotton in one of its most interesting and universal forms, that of the fine and even thread used for sewing. We are bound, indeed, to no less a place than the old-established Boar's Head Cotton Mills of Messrs. Walter

Evans, and Co., at Darley. To this destination we are borne by the early train from Birmingham, catching glimpses on the journey of Tamworth and Burton, one for ever to be associated with the name of the statesman who inaugurated commercial liberty, the other with that national beverage of which we have just written.

Once in the good old town, accompanied by an antiquarian friend whose tendencies lead us to a good old inn bearing the good old sign of "The King's Head," we have leisure to "refresh ourselves mightily" with that same good old ale, and are edified meanwhile by the remarks of our companion, from which we gather that the town occupies the site opposite the Roman station called Derventio; that the Saxon name of the place was Northworthige, the name Deoraby, whether given to it by the Danes or not, being probably derived from the Celtic "dwr" water; that the town was recovered from the Danish conquerors by Ethelfleda, the daughter of Alfred, in 918, and again by Edmund I. in 942. Further, that, in the time of Edward the Confessor, Derby was a royal burgh of 284 burgesses; that it declined in importance for some time, few events of any historical interest being connected with it until the war of the Great Rebellion, when Charles I marched through the town to Nottingham, leaving it to be garrisoned by the parliamentary troops under Sir John Gell. Later, in December, 1745, the Pretender staid there for two days before retreating into Scotland from the Duke of Cumberland.

Setting out presently for the Boar's Head Cotton Mills, and making a slight detour to look at the narrow and winding streets in the old part of the town, as well as to regard the beautiful old tower of All Saints' Church, we become acquainted with that great pride and attraction of Derby—the celebrated Arboretum, consisting of eleven acres of land, which was laid out by Loudon, at the expense of the late Joseph Strutt, Esq., for the benefit of the townspeople.

It is time to resume our journey, however; and, leaving behind us the factories for coachbuilding, silkweaving, ribbed-hosiery weaving, iron-founding, and the formation of those beautiful ornaments of spar, "blue john" and black marble, we turn up the Irongate into the Duffield-road, and commence a two miles walk, in which all the beauties of English pastoral scenery seem to smile on us at once.

Passing the pretty villas which skirt one side of the road, and are half screened by deep clumps of evergreens, golden-flowered laburnum, pink and white hawthorn, and scarlet-blossomed chestnut-trees, all mingling in one exquisite glow of bloom, in contrast with the green meadow-land filled with peacefully-grazing cattle and divided by hawthorn edges, we reach Darley, where the Gothic church, built in 1818, and liberally endowed by the last generation of the Evans family, crowns the hill on my left hand. Here we pass through the beautiful village, where the stillness is broken only by the shrill laughter of children but just liberated from the large schools, of which there are five, for the education of the young workers at the mill. These schools, too, are maintained by a fund left for that purpose by the same family. All the children employed at the Boar's Head Cotton Mills spend a part of each day under the instruction of competent teachers, and are stimulated to diligence and good conduct by the half-yearly distribution of prizes. The cotton-mills themselves were built by the late Messrs. Evans in 1783, but have since been much increased and almost entirely rebuilt.

Crossing a bridge which spans the Derwent where its beautifully wooded banks form a charming accessory to the varied landscape, we inquire for the counting-house, and, explaining the object of our visit, are at once introduced to the younger Mr. Evans, and make a tour of the buildings, up to whose walls the land is shadowed with goodly trees. It is nearly one o'clock before we return to the counting-house; and, the work-people presently coming out in large numbers, we follow the main body of the assembly to the dining-hall, where many of them take their meals, which have already been cooked for them by a woman appointed to that duty.

Many of them, however, disperse across the fields to their own homes, and we should certainly imitate their example by seeking some refreshment in the interval of my visit had we not learned that, for more than thirty years, no tavern has existed in Darley Vale. This is doubtless to the advantage of the operatives employed at the works; for, however picturesque a part of the landscape the "village inn" may have become in some districts, its results are too often to be seen in the squalid degradation of those homes where the children cry for bread, which has been denied

them by those who seek a sottish relief from toil in the drugged liquor of the bar or the brutish revelry of the taproom. Returning to the mill, we very gladly submit to the guidance of the foreman, (who tells us that he was a child in the village fifty-six years ago, having worked forty-seven years for his present employers), and request that we may be shown the whole process of spinning cotton.

As the first step in this direction, we are taken to the "mixing-room," where the bales of cotton, each weighing from 350 lbs. to 400 lbs., are brought from the stores and piled in "bins" or compartments, containing, when full, about two tons each, and arranged one above another according to the quality. The best sort is the American, from which the famous "Boar's Head" crochet cotton is manufactured; for some other sorts the different qualities are mixed, a portion from each "bin" or layer being torn by means of a sort of rake, which gathers, as it is drawn from top to bottom of the various banks or compartments, a definite quantity of each. My conductor informs me that from a single ounce of cotton they spin a thread of from 1260 to 2100 yards in length, according to the purpose for which it is designed; and that in some manufactories they produce a still greater length from the same quantity of material. A ton of cotton, indeed, could be spun into a yarn 25,657 miles in length. The long-established reputation of the "Boar's Head" cotton was confirmed by the award of a prize medal from the jurors of the London International Exhibition of 1862 to Mesrs. Walter Evans and Co., for "strong and superior thread."

Many thousand pounds weight of raw material is daily spun at these mills into the famous "Boar's Head" Perfectionée or embroidery, Knitting, Glacé, and Sewing cotton. Hearing this, we stand gazing in a midday reverie at the immense heaps piled together in the mixing-room, wondering (not being great at arithmetic) into how many billions or trillions of miles it will ultimately be spun; how many reels will be required for its ultimate process of winding; to what remote places it will be consigned; to what diverse grades and characters of the great human family those slender filaments will speak of a common brotherhood. In the midst of a wild whirl of practical romance, "The Autobiography of a Reel of Cotton, with a vivid *dramatis personæ* of slaves and their drivers, cotton lords, yellow million-

aires, poor sempstresses, what not?" we are presented with a cotton-pod, containing the germ of all that we are about to witness, and follow our guide to the "Blowing-room." It is here that the cotton is opened and cleansed from dust and other impurities by being passed into machines consisting of a series of cylinders, through which it is drawn or sucked by a powerful current of air. Upon leaving this machine the material is not only cleaner but more soft and fleecy, and can be removed to the "scratching-machine," where it is subject to the pressure of wooden rollers and afterwards beaten. This gives the mass of cotton the appearance of a sheet of wadding, which is afterwards wound into a cylindrical roll of about three feet in length and nine inches in diameter, called a "lap."

We now follow it to the "carding"-room, where that most wonderful engine the "carding machine" disentangles the fibres of the cotton, and, as it were, draws them out parallel to each other in continuous threads. The "cards," which are a sort of wire brushes, engage the fibres of the cotton as the "lap" is slowly taken up by the rollers of the machine, and comb it into a long and continuous band of fleece about an inch wide by a quarter of an inch thick. This fleecy band, which is called a "rovin," is discharged into a tin can in which it coils itself, as a rope might be coiled in a bucket. Nine of these "carding-machines" can be attended to and kept working by one man.

The "drawing-room," unlike the ordinary apartment bearing that name, is a scene of unceasing activity, where a number of girls are in constant employment watching and adjusting the "drawing-frames."

To these machines the rovins are taken, that the operation begun at the carding-engine may be completed, and by being passed betwen sets of rollers moving with unequal velocity the more perfect and uniform arrangement of the fibre in its entire length is effected, while the inequalities in the soft band or rope of cotton are adjusted. At the first compression of this soft rope this is all that is required, but by two further repetitions of the process (at greater velocity) it becomes drawn out, and at the same time is pressed into a firmer consistency. These drawing-frames are so beautifully constructed that should one of the rovins break during its passage the machine immediately stops, and the attention of the workwoman is instantly directed

to the part requiring to be replaced. The long fleecy rope after the first drawing is about as thick as a bell-pull, but so soft that it may be passed through the eye of a darning-needle.

The more compact thread, or "slub," is now ready for being wound on to bobbins at the "slubbing-machines." At these, each of which carries from twenty-eight to sixty-four bobbins, it is wound singly at first, and then at a similar engine again wound off double, the operation of winding and rewinding being repeated until the filament is in a proper state for conversion into cotton yarn, an operation effected by twisting the threads of two bobbins of the rovin just completed, and at the same time winding them on to another bobbin. The "slubbing-machines" are attended entirely by girls, whose wages average eight shillings a week all the year round.

Even in the primitive and pastoral simplicity of Darley Vale the inveterate determination of following the fashion is exhibited, for here amongst the slubbing-machines crinoline expands to almost dangerous dimensions; nothing seems sufficient to abate this exhibition of female vanity; the presence of peril, the constant recurrence of death by fire, have failed even to mitigate its universal adoption; and the mill hands of Darley no doubt regard their redundant skirts with a complacency as profound as that of their sisterhood in the higher classes of society. Here, however, every precaution has been taken to prevent accidents; all the wheels are covered, and guards are duly fixed at every dangerous corner; in which respect the modern arrangements at the various cotton-mills reduce the liability of the workpeople to accident except in cases of real and almost unpardonable carelessness. Still there are numerous cases where such accidents occur; and it is incumbent on all millowners to secure their workpeople as much as possible even from the terrible results of their own want of caution.

Escaping from this digression, however, we follow the bobbins of yarn to the "twisting-machines," where three or more yarns are wound on to another bobbin, during their passage to which they are drawn through a shallow trough of condensed water, and, at the same time, twisted evenly together. These twisting-machines are also attended by girls, each girl having three machines under her charge.

For the "Boar's Head" six threads of yarn are necessary to make one of cotton; and the machinery for this part of the business is so exquisitely adapted that a child could accurately perform in a single day the work which would at one time have required weeks for its completion. The cotton is next carried to the reeling-room, where it is wound from the bobbins into "hanks," or skeins, ready for the dyer or bleacher. Each machine in this department will wind off forty hanks in twenty minutes; the hanks generally contain about 420 yards, so that in a day of ten hours every woman winds some 290 miles of cotton. The length of cotton in each hank, which varies according to the number or quality, is accurately measured during the process of winding by means of a simple appliance fixed on the side of each machine.

The hanks are next sorted, and the number and quality of each indicated by the colour of the thread by which it is tied. In this condition they are sent to the dyer or the bleacher, and, returning brilliantly coloured or pure white, the cotton is passed over hot cylinders where it is turned until the peculiar curl produced by the dyeing or bleaching is taken out of the skein, and the thread assumes a glossy appearance. It now only remains to wind the cotton on reels, cards, or balls, or to put it up in skeins, according to the purposes for which it is intended, or as it may be ordered by the dealer. The greater part of it, however, is wound on reels by very simple machinery, so adjusted that, by referring to a dial before her communicating with the machine, the winder can regulate the exact length of cotton on each reel. In a day of ten hours a girl can wind from twenty-five to forty dozen reels, each containing a hundred yards. The reels used for sewing-machines contain often 2400 yards, the greatest care being taken to select the strongest cotton, and to keep it free from knots.

In the case of the "Boar's Head crochet cotton" it is necessary (in order to preserve its full strength, and at the same time its soft texture) to wind by the hand wheel, and this operation, which is more ancient than the village itself, is carried on by the people of Darley in their own homes. For this description, and also for the Perfectionée or embroidery cotton, we are told that Messrs. Evans supply so large a demand that it would be impossible to convey, even by means of figures, a certain estimate of the number of yards annually consumed in English homes alone.

As we leave the winding-room our attention is directed to several machines recently invented. These are so marvellously constructed that as soon as a reel is filled with cotton it falls from the spindle, and another, which appears almost impatient to be wound, is immediately taken up to supply its place. By this wonderful adaptation it continues to wind unceasingly at the rate of 190 to 200 dozen reels a day. The glacé thread, manufactured by a machine invented at Darley Mills, is wound on these, and the cotton used in its manufacture is the finest American.

The reels are next taken to the warehouse, where they are packed in dozen and half-dozen grosses—the balls being distributed in half-pounds and pounds, and the skeins in bundles of 5 lb. and 10 lb. each. The packets are then labelled, sorted, and stowed in bins, whence they are sent to the merchants and retail dealers. From the warehouses of the merchant the manufacture of cotton finds its way to all parts of the world, including the original birthplaces of the raw material; from the shelves and drawers of the retailers it is present in every household, helping daily to the amusement of the wealthy and to the support of the poor. In our journey through the mill we are struck not only by the silver-like polish and perfect cleanliness of the machinery, but by the smooth and spotless appearance of the floors. We learn that they are well scrubbed every week, that the stairs are cleaned down daily (a fact attested by the presence there of girls with pail and broom during our visit), and that the entire factory is thoroughly lime-washed once a year.

The lithographic and letter-press printing department of the mill is on a scale as large as that of a printer in an ordinary market-town; and yet it is not idle, for here are produced all the labels, the ornamental wrappers, the bill heads, and the letter headings used at the mills. In connection with this it may be mentioned that the Messrs. Evans are paper manufacturers, their mills for paper adjoining those for cotton, and producing six tons of paper weekly.

One of the most important adjuncts of the cotton factory is, of course, the dyehouse, where the myriads of hanks are dyed in a hundred brilliant colours, of which the newly-invented mauves and magentas are not the least attractive. The foreman of this department is an intelligent and skilful

workman, thoroughly acquainted with his ancient and useful trade.

On leaving the great vats and tubs where the many-hued liquor awaits the cotton, we enter a great yard so piled with timber, large and small, that we begin to fancy there is yet another business in "the vale," and that Messrs. Evans have started in the beam and plank trade. Finding the foreman of the yard, however, we learn that this wood (mostly birch) is used for making the "spools" and reels upon which the cotton is wound. We are shown into a shop where, amidst a maze of straps, driving-wheels, lathes, and circular saws, a number of men and boys are engaged in turning, and are informed that a tree twenty feet long and ten inches in diameter can, in the space of half an hour, be converted into reels; that each of the many lathes turn upwards of thirty gross, or 4420, a day; and that thousands of cubic feet of timber and running feet of birch poles are consumed for the same purpose during a year. The enormous quantity of timber now in the yard seems, and we believe is, sufficient to build a colonial settlement, and yet it is calculated that it will only suffice to supply reels for about two years.

The contrast between the appearance of the people at this mill and that of the hands at many of the factories in various parts of the country is scarcely less striking than the superior accommodation of their dwellings.

The houses in the village contain either two or three sleeping-rooms (according to family), beside living-room, kitchen, and proper offices. To each of them there is attached a good-sized patch of garden-ground, and they are let at from 2*s.* 1*d.* to 3*s.* a week. It might be too much to say that this Derbyshire village is the real happy valley; but it may be safely asserted that both old and young are cared for by having suitable employment provided for them; that for the children there are always at hand the means of instruction; and that Messrs. Evans (following the example of their predecessors) continually endeavour to elevate the social condition of the people by whom they are surrounded.

THE GRAY'S INN PIANOFORTE MANUFACTORY.

WHAT becomes of all the pianos? is a question which we have been constantly propounding to our musical friends any time these ten years, and we have at present found nobody who could give a satisfactory answer. In England, France, Austria, Belgium, Prussia, Switzerland, and America, these instruments are constantly manufactured, while in London alone there are half-a-dozen large "houses," each of which sends out hundreds in the course of a year. The demand never fails, and the supply is fully equal to the constant requirement. New pianos are constantly advertised as being for sale at marvellously low prices, and improvements in construction appear every now and then, each to supersede the last. What, then, we repeat, becomes of the old pianos? A few of them may be seen shattered and wireless, adorning the pavement in front of brokers' shops; but these ultimately find a destination in day-schools, and other localities of youthful education, as being "good enough for strumming on." We can remember having met with sham book-cases which deceived nobody by containing within their depths turn-up bedsteads; but who ever discovered a sham piano? The only suggestion of such an article was that which occurred to the elder Mr. Weller, when he devised his notable plan for enabling Mr. Pickwick to escape from the Fleet Prison, and that fertile expedient was never reduced to practice. The question of the destiny of pianos must remain unsolved, for we have asked Mr. Cadby, who certainly ought to know something about it, and he couldn't tell us. We make this inquiry of Mr. Cadby, while we are waiting in his great timber-yard in the factory at Liquorpond Street: not that that is the object of our visit;—far from it. In despair of finding out where the discarded pianos go to, the next best thing is to see where some of the best come from, and, with an eye to this series of English workshops, to witness the birth, parentage, and education of the instruments which are sent out in all their pristine beauty either to gladden the civilised or soothe the savage breast.

The first object, then, to which our attention is directed is timber, and here it lies in great stacks—rosewood,

mahogany, deal, lime, beech, oak, and all the rest of it, filling the space to which it is consigned for seasoning before being removed to the buildings where it is stored. In the store-room the planks cut from each tree are kept together, somewhat in the form of the tree itself, and stand upright against the walls as if they had been sawn through their whole length while the trunk was still growing. By these means the age, size, and quality of the wood is assorted, and much confusion prevented in selecting material. The centre of the store-rooms is occupied by great piles of dried mahogany, oak, rosewood, walnut, and the other beautiful varieties of ornamental timber; mahogany boards of enormous breadth for the tops of grand pianos, blocks roughly formed for the ultimate manufacture of legs, and large slabs of beech for receiving the pins to hold the wires. We notice some mahogany which has been stored for eight years. It is in thin three-quarter boards four feet wide, and will be used for the tops of pianos made to withstand the climate of India, for to India and Australia, New Zealand and South America, the Gray's Inn Works do a large export trade. The veneers of oak and walnut are not cut from the main tree itself, but from those "burrs" or excrescences which appear to such an enormous size on the trunk; they are cut to a surprising thinness (thirty to the inch) by a knife worked by machinery. This room contains about 80,000 feet of veneers.

Near the store-room is another department devoted to the ironmongery, where bolts, screws, and pins are kept carefully in compact nests of drawers; and here, too, are some of the carved legs and those beautiful fretwork ornaments which are displayed in the fronts of cottage, piccolo, and cabinet pianos, their pattern being relieved by the gay silk lining. Remarking on the apparent fragility of some of these, which are cut into elaborate open patterns, we learn that they are formed of three separate veneers joined into one thickness in such a manner that the crossing of the grain in each veneer imparts an extraordinary degree of strength to the consolidated piece.

In the backmaking-room of the south manufactory the first solid framework of the piano is constructed, and its supporting timbers, already thoroughly seasoned, fitted to receive the superstructure. Here we see some of those massy "grands," and discover that, as a means of additional

strength, their solid cases are formed of five or six thicknesses of timber, the grain of each layer lying transversely to the other, and the whole pressed together in a similar manner to veneering, till the junction cannot easily be detected. In this department we see piles of solid frame-works ready for the operations of iron bracing and veneering. In this, as in various other rooms, there is a hot-air chamber, divided so as to heat a long row of glue-pots and at the same time to warm the wood previous to glueing. The "back," which means the whole solid frame-work, having been firmly braced, and glued, and screwed, the tops have to be veneered by means of the immense screw-presses in the same room, and we follow the completion of the instruments through a number of various workshops.

Not the least interesting of these is that devoted to the preparation of the oak and walnut veneers. These two descriptions are, as we have just said, cut with a powerful knife from the irregular excrescences on the tree. They present the appearance of large circular slices of German sausage or collared-head, and are of about the same thickness, with the additional resemblance of a few holes here and there, where a small piece of fat may be supposed to have dropped out. These holes have to be filled up by a species of inlaying, in which the aperture is brought to a more regular shape by means of a watch-spring saw fitted to a frame. In this, as in the whole veneer department, we are surprised at the wonderful solidity effected by the junction of the woods only through the medium of common glue, under the heat and pressure used in its application.

The upright pianofortes are principally constructed, however, in a large building, called, from its being surmounted with a clock-tower, "The Tower Manufactory." This part of the building is itself about 160 feet long, by 30 feet wide; and at the entrance of the tower a list of the rules and regulations of the establishment is posted, while it is also the central station for a copious supply of water and a fire-hose, which may be carried through the entire building. This leads us to the "stringing-room," where, the beech plank which holds the pins having been veneered with sycamore, and the pins fixed, the strings are firmly fastened and stretched.

The sounding-board is prepared in another room, where the beautiful and somewhat costly Swiss deal, of which it is

composed, lies drying in racks. The perfect completion of a sounding-board is a delicate operation, since its thickness diminishes diagonally in accordance with the length of the string. When finished, its polished surface is almost equal in beautiful concentric grain to bird-eye maple, and possesses a similar silvery vein. The key-making is one of the most important parts of the manufacture, not only because it has to deal with a very valuable material, but on account of the exact level and perfect uniformity, both of motion and surface, which is necessary to secure a true touch in playing. In a room devoted to this work we see the fine white ivory keys being securely fixed to their foundation of wood, which is at present only a solid slab of a proper thickness, with the space for each key mathematically marked out upon its surface. When once the ivory top-pieces are fixed the separation is made, and the long apertures cut for the reception of the black keys. Perhaps no part of the workmanship of a piano requires more care than the proper fitting of the keys and their adjustment. The ivory itself, too, pure, glistening white as it seems, has in it various degrees of grain and shade, so that in fact the keys and front pieces require to be skilfully matched in order to secure the beauty of the whole.

The actions of the various pianos we have already seen in detail in the store-rooms, where hammers, levers, dampers, and the various small and complicated parts are kept ready for giving out to the workmen. The putting of these together so as to secure a free and yet a firm and decided action is of the utmost importance, and presents no little difficulty. This result is facilitated, however, by the original design of the mechanism, and the "new action" pianos at Liquorpond Street seem to have arrived at an admirable combination, which secures a firm blow upon the string and yet allows the hammer to fall freely away in its return, so as to prevent any jar or woolliness of tone.

The fitting-up of the cases and the cabinet-work of the instruments are completed in a room where the racks of dry timber offer a continual supply of material. Here the legs are brought from the heaps of those appendages which we have seen below; here, too, are made, fitted, and polished the doors, tops, falls, panels, and general decorative portions of the woodwork; and upon this floor stands the large

crane, used as a lift by which the instruments are taken from one department to another, as they may be required.

A great sound of one note, or rather of several single notes, vibrating at uncertain intervals and with unusual force, indicates the finishing-room, where the fifty or sixty pianos in progress of completion are under the hands of the tuners previous to their final fitting up. Thence they are taken to the polishing-room, there to receive the last delicate touches which indicate perfection.

The main staircases of the workshops are built entirely of stone, since in case of fire amongst so much inflammable material they alone would secure an escape for the workmen and a free passage for the firemen carrying the hose. The whole of the shavings collected on the various floors pass down a shaft which leads direct to the boiler-room, where they are burned in the furnace. In the boiler-room, too, the glue used in the establishment is made, so that, as it is kept hot in the workshops themselves only by means of steam-pipes, this chance of danger is also avoided.

Descending to this boiler-house, and crossing a section of the timber-yard, we make the acquaintance of one of the faithful servants of the establishment, with whom, having some little influence with his species, we are soon on amicable terms. A very fine fellow he is, too, this noble dog, keeping watch and ward; and we congratulate ourselves upon the sincere welcome he gives us to the premises, as a token in favour of some sort of outward expression of our perfectly righteous intentions.

After taking a glance at the packing-case-making room, at the great warehouse for containing the packing-cases, at the dock vathouse, and the great crane for lifting the instruments into the carts and waggons, we enter the finishing-room for grand pianos, where a number are constantly in progress. In this department the fire-hose is stationed on every landing, and a great tank of water supplies the whole establishment, which is amply provided with lavatories on each floor.

These lavatories, however, are only a part of the arrangement for the comfort of the work-people, since there is a large room in the east factory appropriated as a reading-room; and here the men hold their trade meetings, conduct their benefit societies, have tea meetings (at which their

wives are present), listen to lectures, and occasionally enjoy a concert.

The nucleus of a good library has already been presented to the men by Mr. Cadby, and there is reason to believe that they will organise a society which will offer a good example to the hands in many other large London workshops. It is proposed shortly to employ women in some of the lighter parts of the work, such as loading keys, punching cloth, covering levers, making the woodwork of the action, drilling holes for the pins, &c. A comfortable and entirely separate workshop is now being furnished with the machinery necessary for the purpose.

We have still time to visit in the basement the room where the timber is cut to the requisite shape by means of hand-saw, lathe, planing-machine, and the other admirable but somewhat terrible inventions which deal with a log as though it were so much soft cheese.

The morning is already far advanced, however, and we have not yet visited the show-rooms, where there are more than two hundred pianos, from which to select any variety, from the cottage to the "concert grand." Of the harmonium department, and its beautiful instruments, there is no present necessity to speak, although we are soon convinced, even from a cursory inspection, that it receives as much careful attention as the manufacture of pianos themselves. The specialty amongst the Gray's Inn pianos is Mr. Cadby's own patent, furnished with the "truss bracing," a mechanical improvement, which, applied to the back of the pianoforte, forms a perfect counteraction to the pull of the strings (which is from four to six tons force when the instrument is brought up to concert pitch), and enables the entire pitch to be raised or lowered at pleasure in three or four minutes. The value of this invention can, perhaps, only be understood by those who have experienced the difficulties attending ordinary pianofortes; the occasional straining of the bearings, the "buckling" of the sounding-board, and, at best, the constant tendency to inequality of pitch in the bass and treble of the instrument. This invention has been the means of helping to produce that roundness and delicacy of tone which we noticed in the instruments at the "Gray's Inn Patent Pianoforte Manufactory." But the workshops themselves are an attraction, and the counting-houses and timber-yards are not seldom

besieged with visitors who, with laudable curiosity, desire to learn something of the construction of those beautiful instruments which have come to be the almost necessary appendage to every English home in classes where, but for the enterprise of manufacturers, their acquisition at any reasonable price must have remained as hopeless as it was forty years ago.

Thinking of forty years ago, we are suddenly reminded that here, as in a previous workshop of our series, we are brought back to that great monarch George the Fourth, who made the factories of the coachbuilders once occupying the site of Mr. Cadby's buildings one of the lounges where he might freely display his consummate taste in elegant equipages—an occupation more commendable than some other of the royal amusements, since it set a fashion which gave employment to so great a number of workmen, that they were able to commemorate his Majesty's birthday by drinking an entire butt of porter from Messrs. Reid's brewery hard by.

THE END.

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